COLLEGE OF ENGINEERING CORNELL UNIVERSITY

the Cornell engineer

APRIL, 1957
VOL. 22, NO. 7
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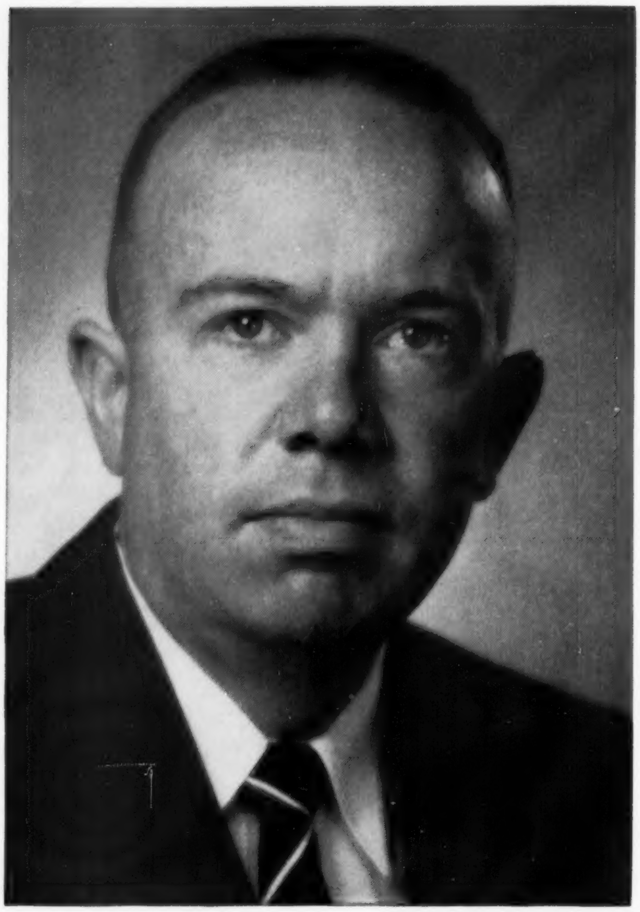
Kenneth A. Brown, class of '46,
speaks from experience when he says:

"There's plenty of chance for advancement at U.S. Steel for the man who really wants to get ahead."



If Kenneth A. Brown were to speak to you face to face, he would tell you: "Hi fellows . . . I'm not much older than you . . . I still like a lot of the same things you do. In addition, I like my work and I sincerely believe that you will like your work at United States Steel, and like the fine bunch of fellows with whom you will come in contact."

Mr. Brown, at the comparatively young age of 29, is presently Works Engineer in charge of all engineering for the Worcester Works of the American Steel & Wire Division. He graduated from Brown University in 1946 with a B.S. degree in Engineering. He first joined U. S. Steel as a Junior Engineer at the Worcester Works, Worcester, Mass. Although his original duties included much drafting, he acquired a general administrative background and engineering experience. This qualified him for promotion to Assistant to the Works Engineer in May, 1950. Despite a tour of military service for two years, Mr. Brown's development resulted in his being transferred to the Construction Division in the Cleveland General Office. Starting January 1, 1953, he worked out of this office as Chief of Party on various construction projects.

On June 1, 1955, Mr. Brown returned to engineering and maintenance assignments at the Duluth Works. Although his work was primarily concerned with engineering problems, he also acquired a knowledge of various phases of maintenance. This experience qualified him for promotion to the position of Division Engineer on April 1, 1956. On January 1, 1957, Mr. Brown returned to the Worcester Works in his present capacity of Works Engineer.

Mr. Brown's "success story" is typical of that of many graduate engineers who have associated themselves with U. S. Steel. "The unlimited opportunities at U. S. Steel," says Mr. Brown, "plus the fine and helpful spirit that exists among the personnel, make success a matter of one's willingness to work to learn and to fit into the friendly atmosphere which exists here."

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THE CORNELL

engineer

APRIL 1957 VOLUME 22 NO. 7

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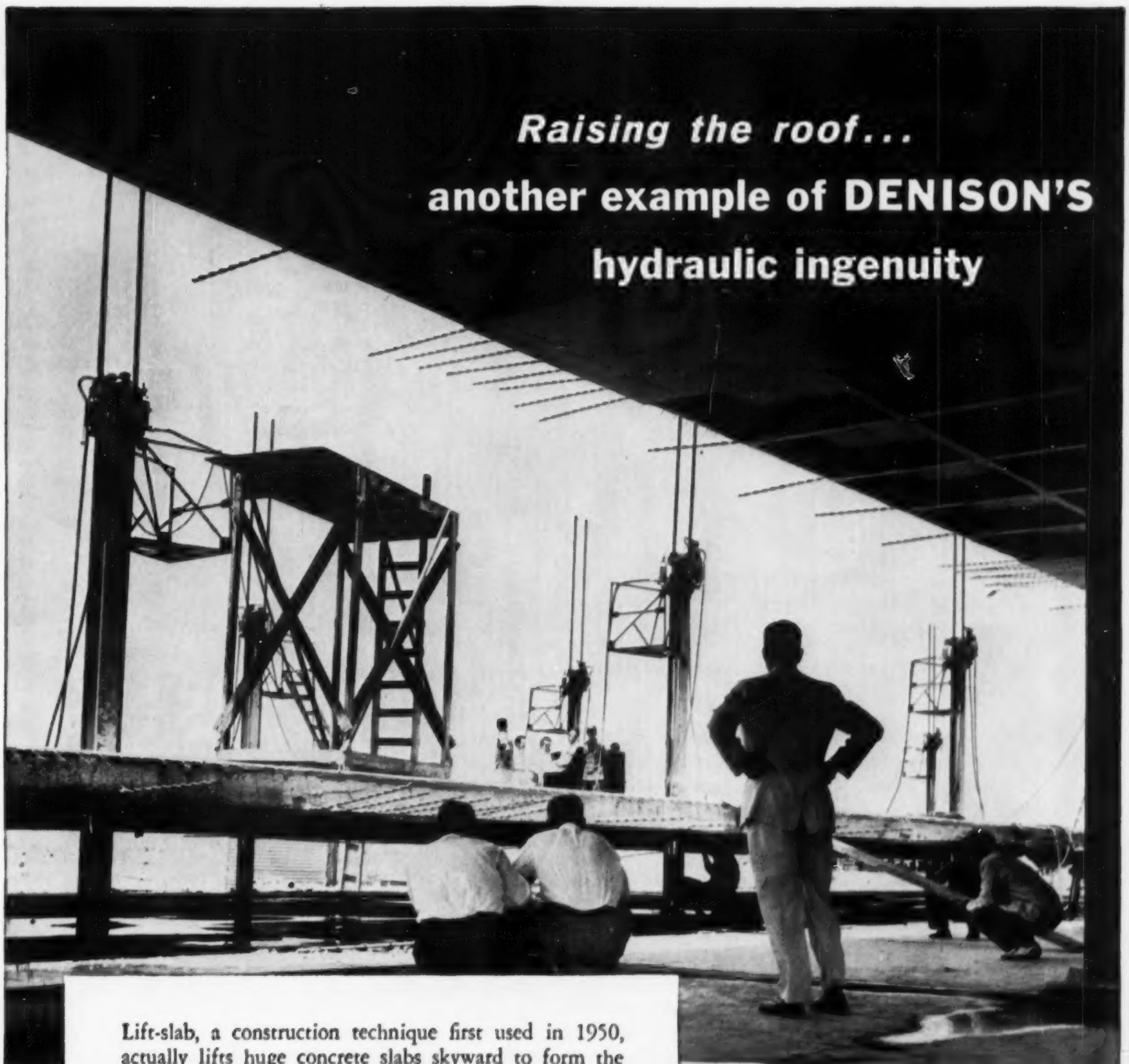
Published monthly—October to May—by the CORNELL ENGINEER, Inc., Lincoln Hall, Ithaca, N. Y. Edited by the undergraduates of the College of Engineering, Cornell University. Entered as second class matter at the Post Office at Ithaca, N. Y., under Section 103, Act of October 3, 1917.

Subscription per year: regular $2.00; with membership in the Cornell Society of Engineers $3.00; student $1.50; single copy $.25.



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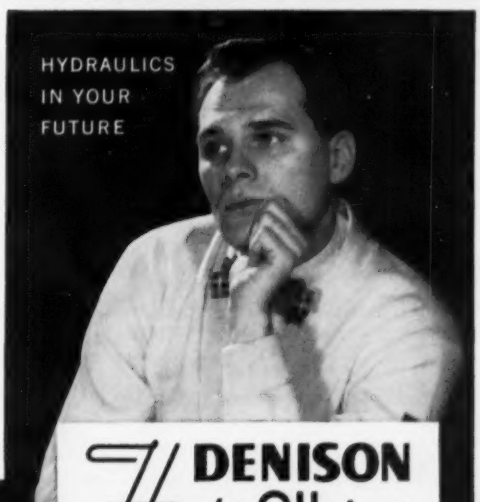

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NUCLEAR POWER
An Economic Survey

by

Irwin A. Kaufman, ChE '55

The utilization of atomic energy for the production of industrial power has been the subject of much speculation and scientific research during the past decade. Once heralded as a limitless source of free power, atomic energy has not yet seen industrial application. The reason is, of course, one of economics and legal restrictions.

Energy Conversion

How is the energy of the atom converted into electrical power? The splitting of a fissionable atomic nucleus results in the liberation of part of the binding energy of the nucleus in the form of heat. The heat of fission of uranium-235 is thirty billion British thermal units per pound. This is equivalent to the heat of combustion of over one thousand tons of coal. It is this enormous amount of heat produced in a nuclear reaction that must be converted to electrical energy. Direct conversion by application of the thermocouple principle has been considered, and such "atomic batteries" have actually been built. The high resistances involved, however, make this method impracticable for producing large amounts of power. A typical battery is one developed by Mound Lab; using radioactive polonium as the power source, it can generate only 9.4 milliwatts of electrical power. Similar batteries have been made by RCA and Tracerlab, using strontium-90 and tritium as power sources, respectively.

The method which has been agreed upon as the most practical, and the one which is being used in the atomic power plants now being constructed or planned, is the utilization of the heat produced in the nuclear reaction for the production of high-pressure steam to drive turbogenerators. The research problems, therefore, center about the development of efficient nuclear reactors and nuclear fuels.

When a naturally radioactive, fissionable element is present in an amount exceeding its critical mass, a self-perpetuating reaction, or "chain reaction", results. The reaction is controlled by the presence of a "moderator" which absorbs or slows down the free neutrons released in the reaction. The heat is removed by a rapidly circulating coolant. The entire device is known as an atomic "pile" or nuclear reactor.

Atomic Fuel

The most prevalent nuclear fuel is uranium. Natural uranium is actually a mixture of uranium-238 and uranium-235 (the fissionable isotope) in a ratio of 139 to one. In a non-regenerative reactor, all the energy must come from the fission of uranium-235 atoms. Uranium-238, however, can absorb a neutron which is moving at the proper speed, and, with the spontaneous emission of two beta-rays, be transmuted into fissionable plutonium-239. In the usual regenerative reactor, an average of 0.8 plutonium atoms is formed for each uranium-235 atom consumed. If the ratio of fissionable atoms formed to fissionable atoms consumed is less than one, the reactor is known as a converter; if the ratio is larger than one, the reactor is a breeder. The increased percentage of natural uranium consumed in a breeder makes the fuel cost for this type of reactor appreciably less than for a converter or a non-regenerative reactor.

Substances which are commonly used as moderators are graphite, heavy water, and berillium. Coolants include water, heavy water, gas, gas under pressure, and liquid metals. Removing the heat by a circulating coolant is more economical than absorbing it in an endothermic chemical process.

Design Operation

A single-purpose reactor is designed and operated to produce power as cheaply as possible. Any by-products formed that have nuclear fuel value are used as fuel for the reactor, and their value is assumed to be small compared to the total cost of producing power. A dual-purpose plant, on the other hand, recognizes the greater value of plutonium as material for atomic weapons than as a nuclear fuel and is designed and operated for maximum efficiency in plutonium production. The economic feasibility of dual-purpose plants is guaranteed by military demand for plutonium. It is believed that the price the government will pay for plutonium is great enough to offset all costs of fuel, labor, materials, and supplies for the power plant. Economic studies of dual-purpose plants are misleading, however, because they make no allowance for changes in the demand for plutonium.

The physical difference between a coal-burning power plant and a nuclear power plant is the replacement of the conventional boiler and fuel-handling equipment with a nuclear reactor. The boiler and

←

Physicist at North American Aviation, Inc. checks core for research reactor located on the campus of the Illinois Institute of Technology.

Two scientists inspect the Illinois Institute of Technology reactor, core of which is shown in frontice. The scientists are checking a shielding plug in one of the experimental ports of the reactor.

fuel-handling equipment in a conventional power plant has a typical value of $77 per kilowatt of installed capacity. The capital cost of a nuclear reactor and associated equipment is about $300 per kilowatt of installed capacity. The high capital cost is due to the large area of land needed as a plant site because of hazards, fuel fabrication and processing equipment needed to remove fission products and to recover and repurify fuel, heat transfer equipment, and the fact that nuclear reactors are expensive. In addition, operating costs are increased because of the necessary chemical processing, shielding, remote controls, insurance against hazards, and waste disposal problems which accompany nuclear reactors.

The saving in the cost of producing power will have to come from the fuel cost. The fuel cost in a conventional plant is approximately 3.4 mills per kilowatt-hour. This represents 30 per cent of the cost (including distribution costs) of industrial power, and 12 per cent of the cost (including distribution costs) of domestic power. These percentages are the maximum possible saving by substitution of atomic fuel for coal. Comparison of fuel costs between conventional and nuclear plants depends upon the type of reactor employed. Natural uranium costs $35 per pound, but only 0.7 per cent is fissionable. The fuel cost in a non-regenerative reactor, in which just the uranium-235 is utilized, is 7 mills per kilowatt-hour. Fuel cost for a converter, in which one per cent of the natural uranium is consumed, is 1.3 mills per kilowatt-hour. Fuel cost for a breeder in which 50 per cent of the natural uranium is consumed is 0.026 mills per kilowatt hour; if all the natural uranium is consumed, the cost is 0.013 mills per kilowatt-hour. Fuel cost for a breeder is almost negligible compared to total operating costs. The annual uranium requirement of a plant of 200,000-kilowatt installed capacity is 77 tons for a non-regenerative reactor, 27 tons for a converter, and 540 pounds for a breeder with 100 per cent consumption of uranium.

The key to economic feasibility for single-purpose nuclear plants is the development of economic breeding reactors. Economic feasibility with present reactor design is a reality, however, in areas where costs for conventional fuels are high. Many European countries are in this classification, and one of them, Switzerland, is building a nuclear reactor. The reactor, which will cost over four million dollars, is being built by three Swiss power companies.

A.E.C. Reactor Studies

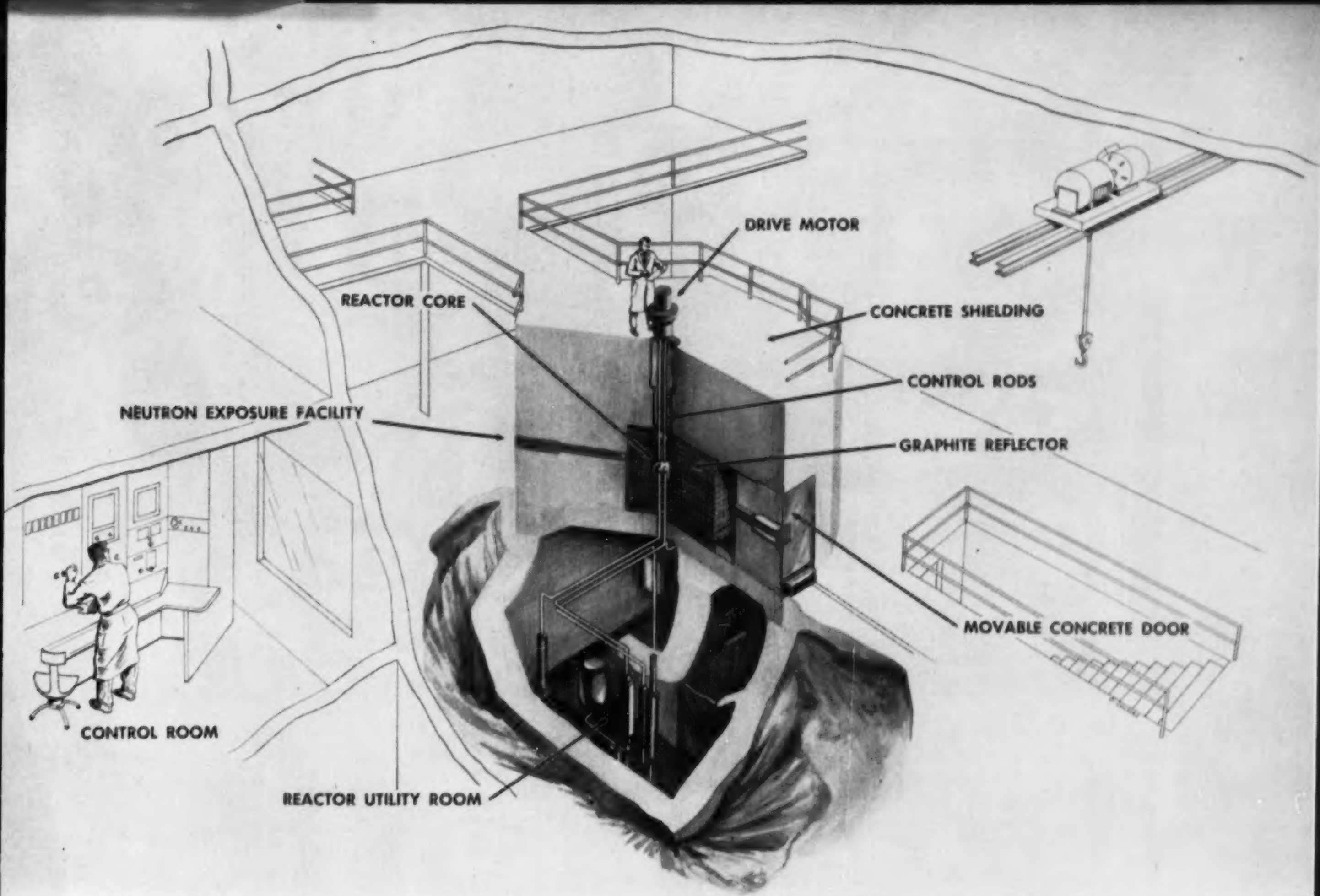
The situation in this country, where fossil fuels such as coal and oil are cheap and abundant, is not as promising at the present. The Atomic Energy Commission does not believe that atomic power will be a competitive economic reality for at least ten years. This opinion is substantiated somewhat by the results of studies made by four industry teams under the sponsorship of the A.E.C.

The Dow Chemical Company–Detroit Edison Company studied a liquid-sodium-cooled fast breeder reactor using uranium-235 fuel continuously moved through the reactor and the processing operations as molten metal, metal slurry, or fused salt. The economic analysis of this reactor shows that it will not be competitive until after the initial 5-year amortization period, because of high fixed charges during the period.

The Commonwealth Edison Company–Public Service Company of Northern Illinois studied two conventional thermal, non-breeder reactors: one was helium-cooled and graphite-moderated; the other, deuterium-cooled and deuterium-moderated. The helium-cooled reactor requires an investment of over $800 per kilowatt of installed capacity, which is excessively high. The deuterium-cooled reactor requires $560 per kilowatt of installed capacity. The cost of deuterium is 40 per cent of overall cost. Using light water for cooling and moderation would reduce the total cost by $47,000,000, but would require the use of enriched uranium as fuel rather than natural uranium.

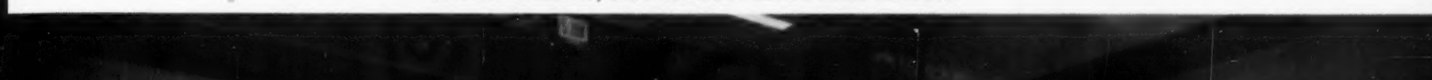
The Monsanto Chemical Company–Union Electric Company of Missouri studied a liquid-sodium-cooled, graphite-moderated thermal reactor using enriched uranium as

(Continued on Page 60)



Artist's sketch of the Illinois Institute reactor. Atomic fission, which takes place in the reactor core, center, produces radiations useful in medical, industrial and scientific research. The reactor will be located 5 feet underground and will be shielded by five feet of dense concrete.

Technicians (left) check a shielding plug in the I.I.T. reactor. At right is the mechanism that closes and opens the 40,000 pound door of the reactor; the core will be buried under this floor.



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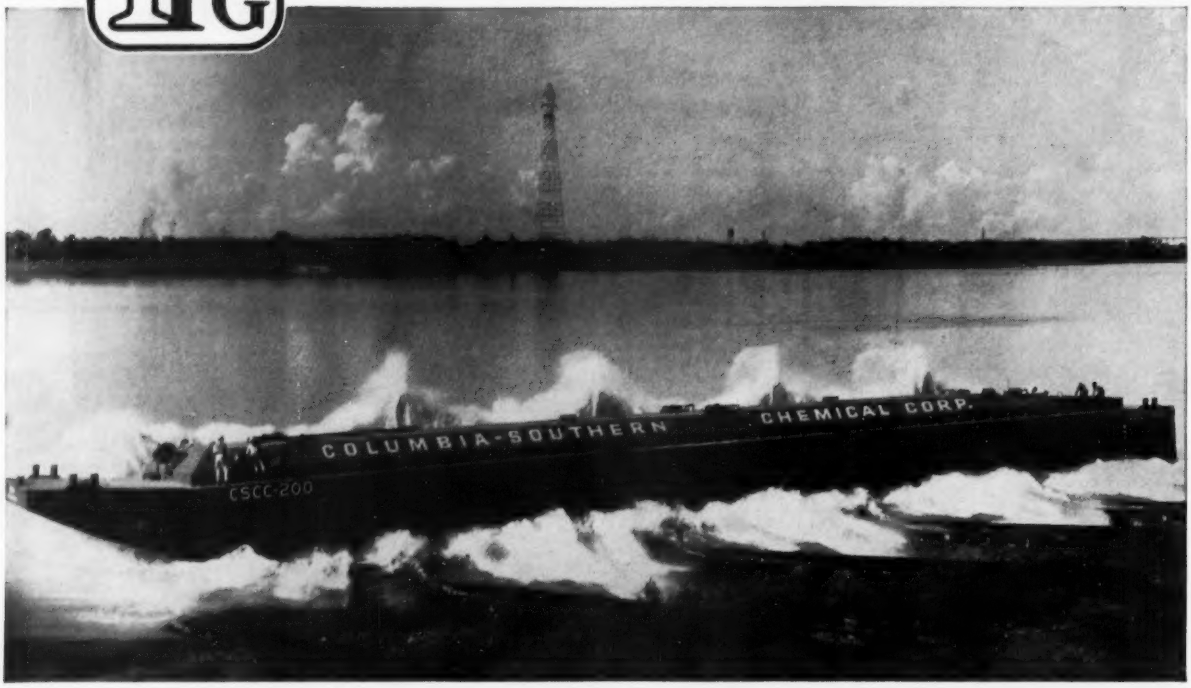

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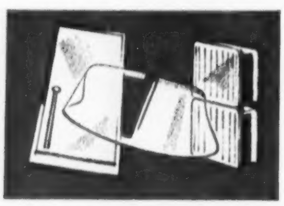

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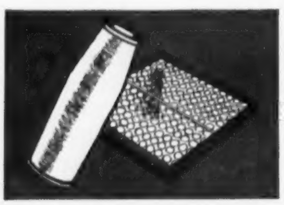

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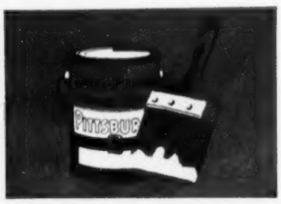

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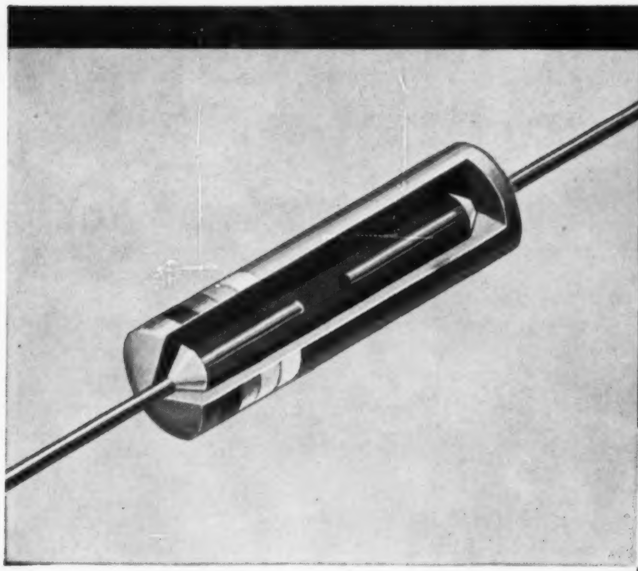
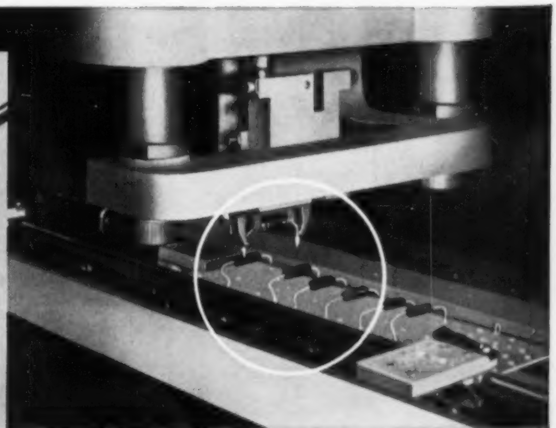
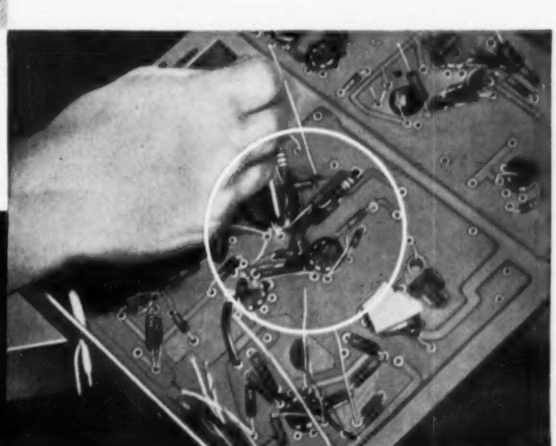
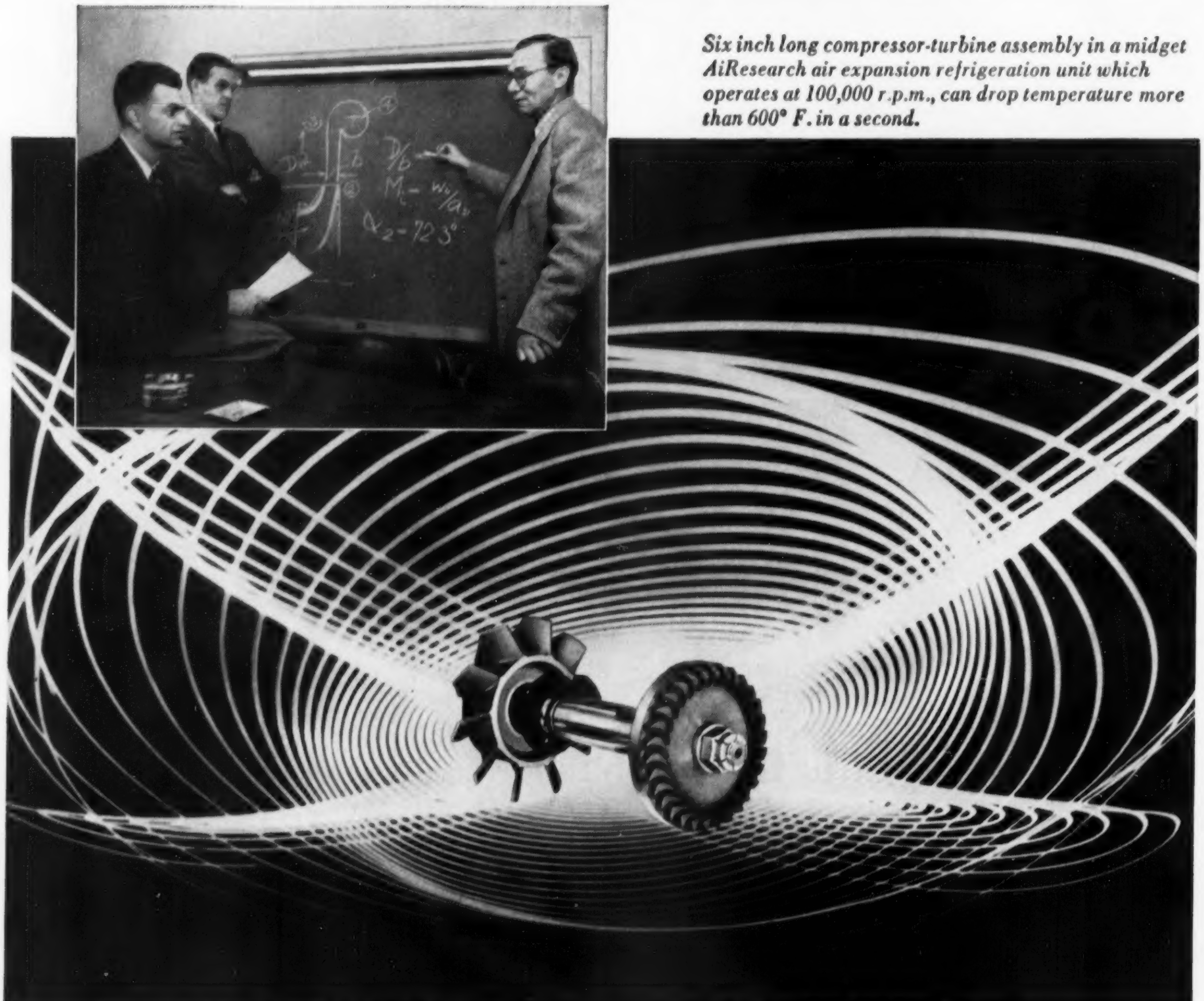






To the engineer who intends to blaze *new* trails...



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RHAPSODIES IN WRAPPING PAPER

by
Harvey N. Roehl, ME '49

In an age when "nucleonics," "automation," "autonetics," "electronics," and "autodynamics" are common words among engineering minded people, it is no wonder that one of the most fascinating mechanical developments of a scant thirty or forty years ago has been all but forgotten. Forgotten to the point where a good many of the younger readers of this article have probably never even seen or operated one of the machines to which we refer—the mechanical piano! Yet the fabulous industry which developed and produced literally hundreds of different types and makes of these machines was once the most fertile field imaginable for whoever would be ingenious in the ways of gadgetry and musical whimsy.

Developed by 'Gadgeteers'

Today we hear much of 'Engineering' and 'Development'. It is questionable whether much real engineering was done in this industry in the sense that most of us think of the subject today—what with complicated mathematical tools, formal educations in the subjects, experts and consultants in particular fields, and so forth. But there certainly was an astounding amount of development and research work done. The engineers—or perhaps we should say gadg-

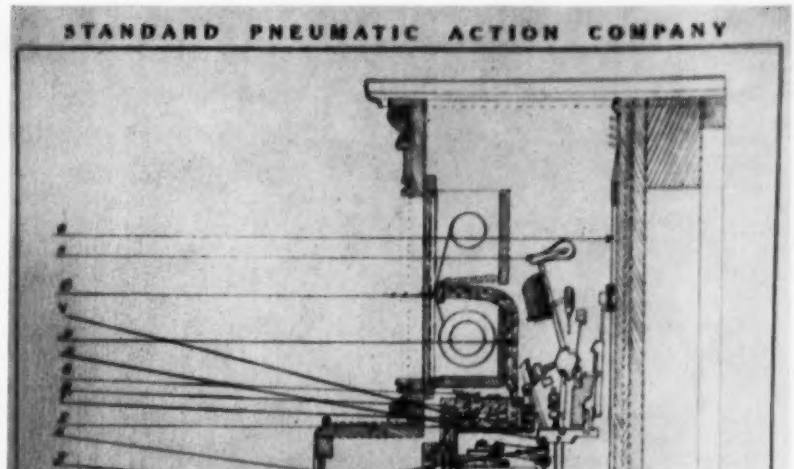

Fig. 1: Cross-sectional drawing of an ordinary home-type player piano, fitted with a player action manufactured by the standard Pneumatic Action Co.

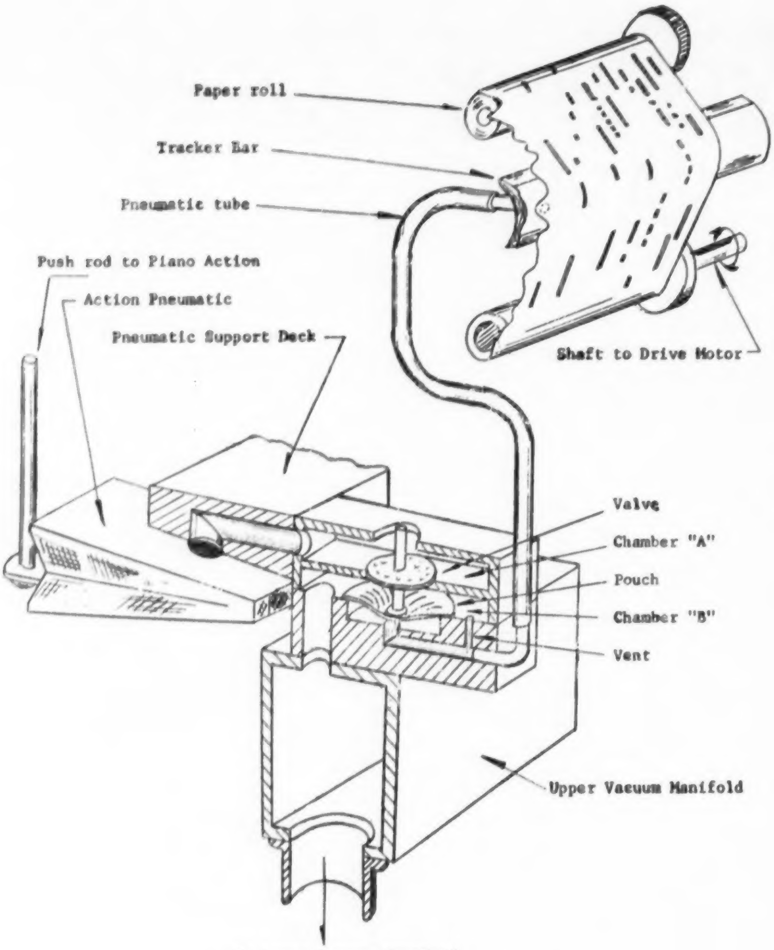

Fig. 2: Single Valve Pneumatic Action.

eteers—in this business managed to develop the player piano to the degree where in its highest state it was able to reproduce perfectly the exact impressions and expressions of the great pianists of the day who were called upon to permit the machines to reproduce their artistry upon a punched paper roll. Today we hear much talk of servo systems, feedback circuits, linear programming, and so forth . . . all of which is old stuff to the player piano business, even to inventors who never heard of a differential equation or a LaPlace Transform!

Unfortunately, the piano industry characteristically is poor at record keeping, and somehow the general public never has had much interest in what a piano is all about other than the fact that it should be a nice piece of furniture. The result has been that very little has ever been placed in print about pianos in general, and practically nothing at all about player pianos. A good example of lack of information is the LINK Company of Binghamton, New York—now LINK Aviation, Incorporated. Several old timers who worked in the factory at various times during 30 years of player piano manufacture have told the writer that there never was a blueprint in the place. All parts were made from sketches on pieces of wood! This means that to piece together today a comprehensive history is all but impossible; but we can go back through the years and get an over-all picture of the industry, and see some of the contraptions that came upon the scene.

Early Development and Operation

Opinions differ as to who should get credit for the earliest development, but the majority of evidence points to a Frenchman named Forneaux who perfected in 1863 a machine which could be wheeled up to the front of an ordinary piano, such that fingers on the back of the machine would contact the keyboard and play upon the notes according to the dictates of perforations in a piece of cardboard set into a slot. The whole thing was operated by turning a crank on the front, much like a hurdy-gurdy. Forneaux's machine was not a commercial success, but it received a certain amount of attention and in fact formed the configuration of the mechanical player as it existed until about 1906, that is, a "wheel-up" or "push-up" attachment to play the keyboard of a normal piano. These began to appear commercially in the very late 1800's.

But all through the years, in spite of additional complexities, the basic mechanism for striking a key on an impulse from a hole in a perforated sheet has remained the same and it is well that this be reviewed before examining various types of machines. To begin with, a vacuum is produced. In the home style pianos, this was generally done by pedalling with the feet to open and close large exhausting bellows, as at "B" in Fig. 1. This vacuum is delivered (if we may speak of vacuum as a positive quantity) to a manifold "T" in Fig. 1. From here refer to Fig. 2, enlarged for purposes of clarity: note that the vacuum is at all times in chamber "B", from which it can pass through the small vent hole to be not only on both sides of the flexible leather pouch, but also to enter the pneumatic tube connected to the tracker bar. This means that the pouch has equal pressure on top and bottom, and therefore would not assume any particular position except that it is connected to a leather-faced valve having both an upper and a lower seat. Note that the top of the valve is exposed to atmospheric pressure, while the bottom is exposed to vacuum and this forces the valve to the seat on the vacuum side. This then means that the "action pneumatic" (in player piano terminology, small bellows are called "pneumatics") is filled with air at atmospheric pressure.

(There is one of these complete set-ups in the piano for each note to be operated mechanically, which means 88 in most home style pianos. Obviously, then, the parts are

small and must be compact. The action pneumatics are generally 3 to 4 inches long and about an inch wide.)

Now suppose the paper roll advances to a perforation and the pneumatic tube is exposed to the atmosphere. Atmospheric pressure enters under the pouch, raising it by virtue of the fact that the vent is small in diameter compared with the other passages. Raising the pouch raises the valve, cutting off the opening of atmospheric pressure to the action pneumatic and connecting vacuum to it through chamber "B". The pneumatic therefore collapses, raising the push rod to the piano action and striking the hammer to the strings—or perhaps performing some other ingenious function such as striking a drum, beating a cymbal, or making an adjustment (a servo function).

It takes quite a few words to describe this process, but it doesn't take very long in practice. A player mechanism in good working order can repeat this process ten times per second. And, of course, the careful reader will notice that the mechanism in Fig. 2 is slightly different from that in Fig. 1. Fig. 1 is a cross section of what is known as a "double valve" system, which amounts to two valves like Fig. 2 in series for each striking note. The writer has both single valve and double valved pianos in his collection, and both seem to work very well. However the manufacturers of the double system claimed that their devices permitted faster repetition of notes, probably owing to the fact that the first or primary valve could be quite small and therefore act as a relay for the second. This in turn meant that a smaller impulse of air at atmospheric pressure acting through the paper roll would start the train of events.

The early types of commercially available home style players, as mentioned previously, were those that would play the keyboard of a regular piano. These devices were generally similar to the one illustrated in Fig. 3; in order to accommodate different pianos the casters were adjustable up and down (fortunately, key widths are standard). Machines of this type are strictly collectors' items and museum pieces today, and so are the rolls that fit them. The early players used rolls that played 65 of the 88 notes on the piano keyboard, and the players were constructed accordingly, with the tracker bar having six holes to the lineal inch to match the paper perforations. These early rolls are quite scarce, but are quite interesting because they represent the first attempts to catalog the outstanding classical compositions of the day. But of course the re-arrangements necessary to squeeze a full 88-note composition into a range of only 65 notes often meant pretty thorough mutilation of the original writer's aims!

One of these machines, the PIANOLA marketed by the Aeolian Company of New York City brought to the American scene a trade name that became practically a generic term applied to all player pianos. There were any number of attempts by other manufacturers to coin a title that would be as catchy to the public ear, but all have been long since lost by the wayside. Who can remember the Auto-Tone, the Auto-Manual, the Playold, and Piola, the Pianoleno, the Tone-Ola, or any of the myriad others that appeared?

Shortly after the turn of the century, various inventors managed to build player mechanisms small enough to fit inside the cases of regular upright pianos; this was considered a very desirable situation because it eliminated the necessity of wheeling around an essentially cumbersome contraption in order to play mechanically. In addition, it would mean just that much less cabinet work, a lower overall cost, and consequently a greater market not only for pianos but for rolls as well! And while all this was going on, the fertile minds of these fellows were also occupied in ways to make the mechanisms more compact and less expensive to produce, with the ultimate aim of an inexpensive player for all eighty-eight notes of the piano!

While it is not clear just when the first 88-note player was built, it is evident that by 1910 the push-up player was a thing of the past, and also were the 65 note rolls. By that time the typical home-style player piano was practically at the peak of its development and the only changes that were made between that time and the present were in the class of refinements, rather than new concepts. In fact, in November of 1956 the Hardman Peck Company of New York introduced a small player piano to the

Fig. 5: Scenes from the research and development laboratories of the American Piano Company.

market ($1295.00) evidently to help meet the demand of people who are now scrounging the countryside for machines to fill in their game and recreation rooms. For all practical purposes this machine is the same as those of 45 years earlier—at least as far as mechanism goes. But to be sure, it is a nicer looking piece of furniture!

As might be expected during the period of transition from 65 note rolls to 88 note rolls (which have perforations spaced nine to the inch instead of six), a number of players appeared on the market which would accommodate either size by a manipulation of the tracker bar. In fact, at least one machine was marketed which would accommodate not only these two sizes, but three other sizes as well which somehow appeared on the scene!

The Expression Reproducing Piano

The statement that the *typical* home player did not change much in 45 years is a bit misleading, because during the period from 1907 until 1929 a great deal of development work was done on what is known as the *expression reproducing piano.* Evidently the first commercial effort in this direction came from Germany, with M. Welte & Sons of Freiburg marketing a machine called the "Welte Mignon" which was capable of rendering, automatically, music for all practical purposes exactly the same as what the artist could play by hand. These pianos are not considered to be typical, because owing to their mechanical and pneumatic complexities, they were expensive, and consequently found their way mainly into the homes of the wealthy. In addition, because they were complicated, there were never very many service men who could understand them—much less repair them—and consequently few of them ever worked very well for very long. There are very few people around today, including professional piano technicians, who have much appreciation of how magnificent some of these machines were.

With the exception of a couple of magnetically operated players that appeared on the market, practically all of the expression reproducers worked on a very simple principle. The upper vacuum manifold (see Fig. 2) was divided into two halves—a bass half and a treble half. Each of the halves received its vacuum from a pump in the lower part of the piano (usually electrically operated to insure uniformity of pressure) through a variable rate valve. This valve was in turn positioned by extra perforations in the sides of the paper rolls. But as is often the case, in order to get simple principles to work a lot of extra gadgetry is necessary (modern aircraft jet engines are a good example) and a glance at Fig. 4 will illustrate this point.

It is apparent that under these conditions, with as many as 16 dynamic gradations of intensity available through each half of the vacuum manifold, that delicate shadings of expression were indeed available; but it is also apparent that while expression was available for both bass and treble sections of the keyboard, no variation was possible between individual notes in either section. This means that these pianos made no variation of intensity of striking the notes in a particular chord normally played by one hand, for example. But the odd part is that this fact seems to make little difference. Accomplished musicians have difficulty, in fact in most cases can not recognize that music emanating from these machines is reproduced mechanically.

The AMPICO, along with the Welte Mignon and the Aeolian Duo-Art, represented the best known names in the reproducing field. The early Welte was, as mentioned, a German development, but this machine appeared also in a modified American Licensee form produced by the Auto-Pneumatic action company of New York City.

Promotional Techniques

The producers of these pianos went to no end of trouble to get the great artists of the day to permit their work to be reproduced for sale to the public in the form of rolls. The names of Paderewski, Gershwin, Saint Saens, Gieseking, Grieg, and all the others abound in the elaborate catalogs of offerings put out by these companies, and in the monthly supplements to the catalogs. In most cases, signed testimonials from the artists appeared in the catalogs. A favorite stunt with the promoters of these pianos was to stage a con-

Fig. 3: The Pianola. Self-playing push-up players of this type were popular in this country around the turn of the century.

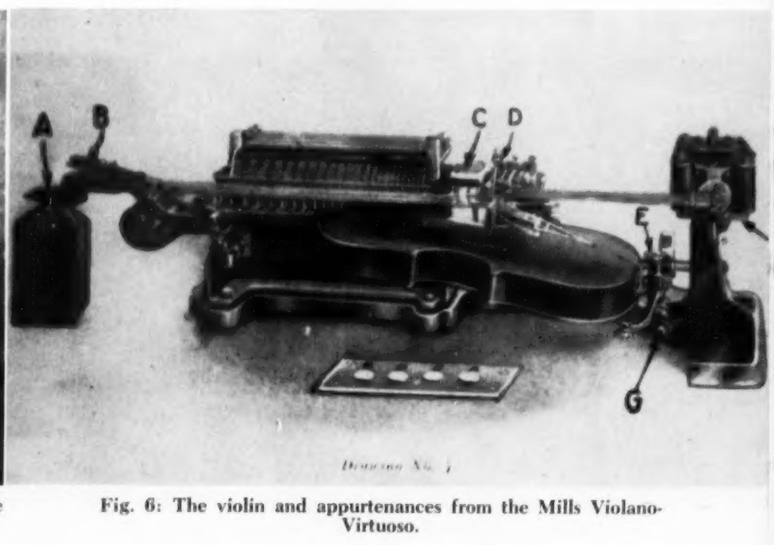

Fig. 6: The violin and appurtenances from the Mills Violano-Virtuoso.

cert with a famous pianist accompanying an equally famous orchestra on a legitimate concert stage such as that of Carnegie Hall. After rendering some compositions, perhaps half way through one, the pianist would suddenly get up from his seat and walk off the stage, leaving the piano automatically continuing to accompany the orchestra, the audience never having realized that the entire number had been played automatically right from the start! From the standpoint of development, if any real engineering was done in this business, it was in refinements to the reproducing pianos. The first AMPICO, for example, appeared around 1915, but all the time a research group was busily engaged in improvements to the end that in 1929 an entirely new mechanism was marketed. Unfortunately, the depression pretty well finished what little was left of the player piano industry after the radio and phonograph business all but killed it in the 1920's, and the later AMPICOs are now rare indeed. Fig. 5 shows the AMPICO staff hard at work on new gadgeteering! Of course desperate efforts were made by some manufacturers to hang on to the sales of players in spite of competition, to the point where at least one concern introduced a player with a phonograph inside the case, and it is said that others were brought out containing radios.

But the ordinary typical home player was at best a pretty honky-tonky affair—interesting perhaps, amusing certainly, but offering little in the way of real musical satisfaction. So it is no wonder that the demand for them quickly diminished almost to nothing for 30 years, to the point where only one of the many companies producing rolls was able to survive to supply the needs of the few "music lovers" who had kept their machines in repair. This one concern is the Imperial Industrial Company of New York City, which has a staff of 15 or so getting the latest hits of the day to market under the trade name "Q.R.S."

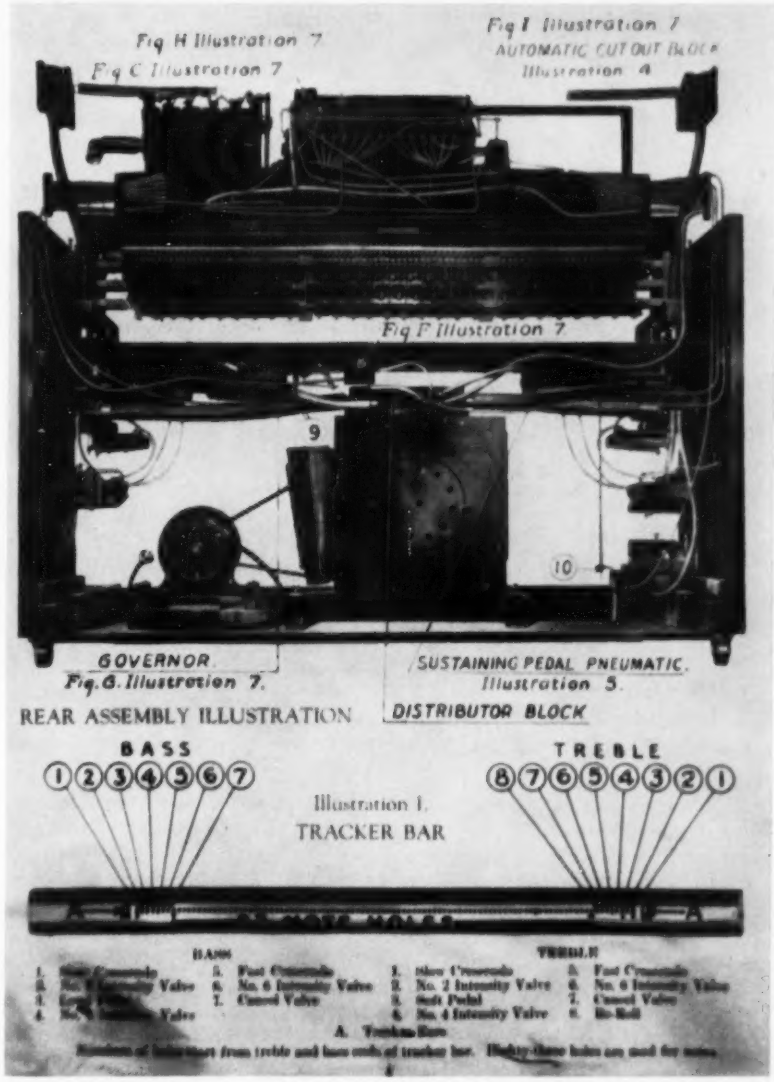

Fig. 4: The back side of the AMPICO upright player mechanism, showing the position of the parts in the piano case. The lower view is of the hole layout of the tracker bar.

Present Use

So what is the future for player pianos? There is a large demand for them nowadays by people who have recreation rooms and think that they are a lot of fun, to the extent that there aren't enough of them in working order to go around. One newspaper recently estimated that there are probably 100,000 of them still in existence in the country, but the important question is how many of them actually work, because the greatest enemy of these machines is disuse. Rubber parts characteristically tend to harden with age if they are not flexed occasionally, and this means that if a player has been unused for any length of time chances are it must be completely re-built and all tubing replaced and all pneumatics recovered . . . needless to say, a substantial undertaking. To make matters worse, most of the player piano technicians of the old days are now gone or retired, and very few modern day tuners and repairmen even have bothered to try to understand player mechanisms. The few that do understand them generally dislike working on them, because more money is to be made in tuning—in addition to which very few people are willing to pay the cost of a complete rebuilding.

To be sure, there have been recently and are now players on the market. In 1950 the Aeolian American Company introduced a new type Pianola, but it was withdrawn from the market after a few months. In 1954 the Gribble Music Company of Kansas City introduced an attachment called the "Magic Fin-

gers", developed by the Midwest Research Institute. Interestingly enough, History repeats itself here as elsewhere. The earliest players were attachments, and now the newest is also an attachment although in slightly different form. Sales of this piano, however, have evidently not developed to the point where it can be considered a commercial success. The Hardman Peck machine was mentioned earlier. Unfortunately, even in its simplest form, a player is a fairly complex machine that requires much hand labor, and therefore the cost is not likely to get down to the point where any mass market is again going to be realized. So the best conclusion that can be made as to the future of the player piano is that it will become more and more of a collector's item as time goes on, and consequently more and more of a novelty to succeeding generations.

Coin-operated Machines

But no story of the player piano would be complete without going back to the beginning and reviewing some of the efforts put forth in the field of coin-operated machines for places of amusement. This is the area where the gadgeteers really had their field day, because the general idea seemed to be to get as many instruments as possible squeezed inside the piano case to supplement the music of that instrument—and often the results were truly astounding!

The LINK Company previously mentioned, for example, was the successor to the Binghamton Automatic Musical Company which was founded around 1900 . . . this concern is known to have produced a variety of types of instruments, but one of the first is the coin-operated automatic xylophone. Shortly after this device came the automatic pianos into which were placed xylophone attachments as well as sets of wooden flute pipes, drums, cymbals, castanets, etc. Mr. E. A. Link gained control of this organization around 1910 and from then until 1929 manufactured both automatic pianos and pipe organs. This company would have passed into oblivion like most of the rest, had it not been for the aeronautical interests of his son, Mr. Edwin A. Link who built an aviation flight trainer utilizing many principles of player piano construction and was able to build a very substantial business out of it. Player piano enthusiasts can feel right at home in examining a World War II Link trainer—they are full of bellows, pneumatics, and other closely related paraphernalia. (Author's note: At this writing, Bill Link, grandson of the founder, is a Cornell Engineering Student.)

One of the greatest American music houses, Wurlitzer, produced a tremendous number of automatic pianos of all varieties—from the simplest 44 note Pianino for small gin mills to the large photoplayers for silent motion picture theatres. These machines were basically pianos, but they had separate cabinets containing drums, traps and other noisemakers. The roll mechanisms were also unique. There were automatic changing devices which could be controlled by the motion picture operator from his booth, so that merely by pressing the proper buttons he could change from struggle music to chase music to sob selections to meet the varying needs of the scenes upon the silver screen! And of course Wurlitzer had a large business in Military Band Organs—not really pianos, but certainly related—which were used in skating rinks, large dance halls, and merry-go-rounds. The Artizan Company and the North Tonawanda Musical Company were also active in this field.

One of the great Juke Box names of today—Seeburg—owes its existence to the preceding automatic piano business. This was a very aggressive concern from the standpoint of merchandising, and their machines were sold far and wide . . . machines ranging from relatively small pianos without keyboards, to giant orchestrions ten feet tall, loaded with gadgets and doodads in addition to the piano itself.

The list of names is almost endless. Coinola, Electrova, Nelson Wiggen, Welte, Hupfeld (German), Tangley Calliophone, Cremona, Regina (now a vacuum cleaner), Peerless, and many others are now forgotten by all except a few diehard collectors and a few museums which specialize in this sort of thing. One of the outstanding collections in the East is operated by the Sanders family in Deansboro, New York (near Utica); the Lightner museum in St. Augustine has some machines, the D. Cameron Peck auto collection

(Continued on Page 60)

AUTOBIOGRAPHY

Harvey N. Roehl was graduated summa-good-riddance from Sibley in 1949, after starting in 1941. A native Ithacan, he is the son of the late Professor L. M. Roehl of the Agricultural Engineering Department, a fine musician who spent no end of money to see that his sons had fine musical educations—only to have this one drag a beat-up old player piano into the basement of the family homestead at the earliest opportunity!

Harvey tried working for a couple of years after leaving Ithaca, but finally decided that teaching is an easier way of making a living. Presently he is Director of Extension work at Broome Technical Community College in Binghamton, New York, is a member of the Cornell Society of Engineers, and holds a New York State Professional Engineers License.

Most of the material in this article was extracted from a picture scrapbook of player pianos which he is writing, and which is to be published by Century House of Watkins Glen, New York, sometime in 1957.

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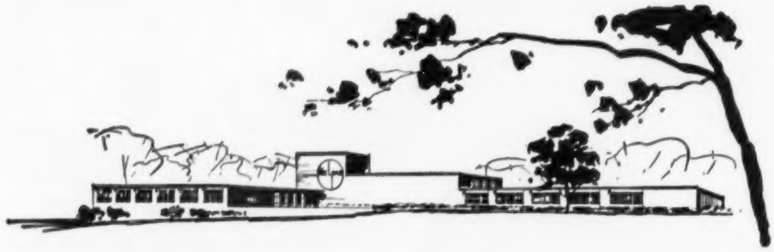

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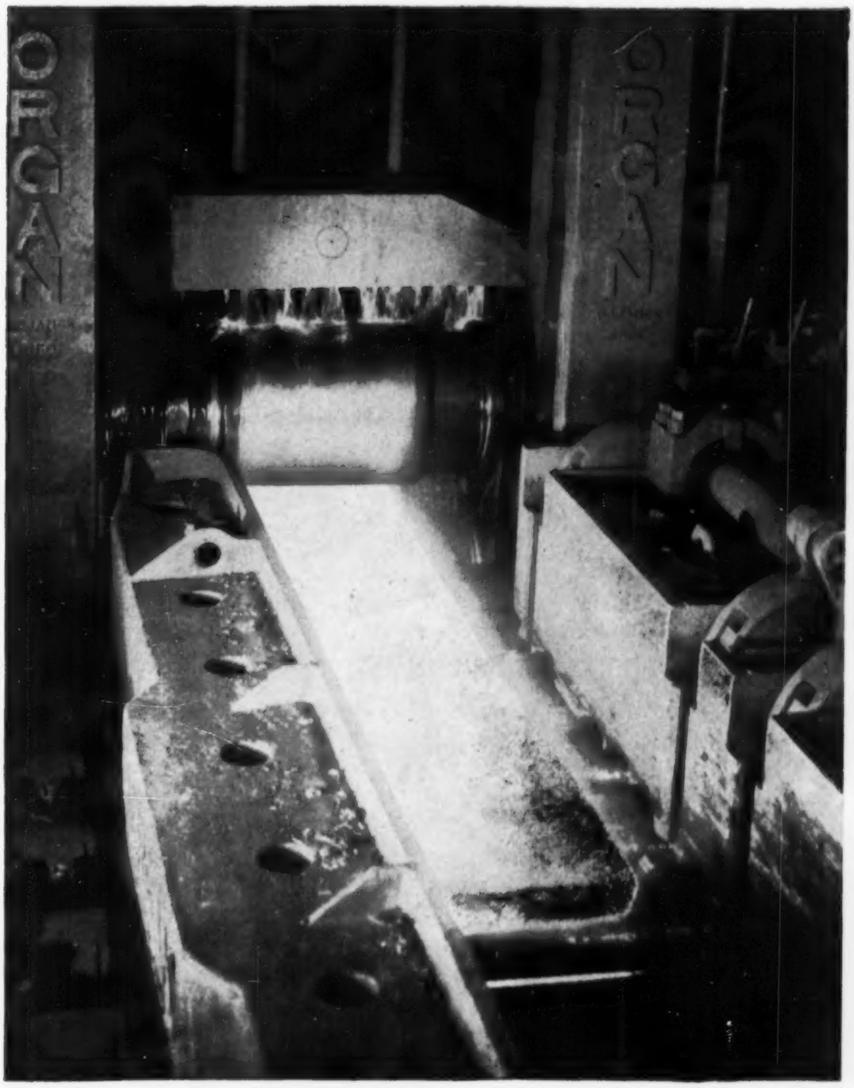

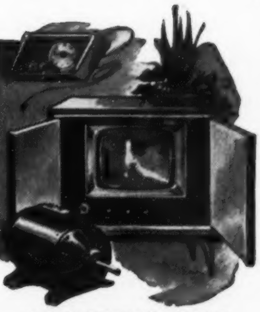

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EARLY DEVELOPMENT OF THE PETROLEUM INDUSTRY

by

David S. Lermond, ChE '57

Fifty years ago the refining of crude petroleum involved very little engineering. The most important product was kerosene, then widely used in cities, towns, and villages for burning in lamps as a source of illumination. A simple distillation was sufficient to produce this material. Today gasoline with special characteristics is required for modern combustion engines in automobiles and aircraft. In addition other chemical products such as alcohols, synthetic rubber, and aromatic hydrocarbons are produced from petroleum.

Early Uses

History is filled with references to oil in one form or another. Pitch was used for mortar in the walls of the tower of Babel. Egyptian kings used petroleum to lubricate the wheels of their chariots. More than two thousand years ago the Chinese used natural gas for both heat and light in their homes, piped through hollow pieces of bamboo.

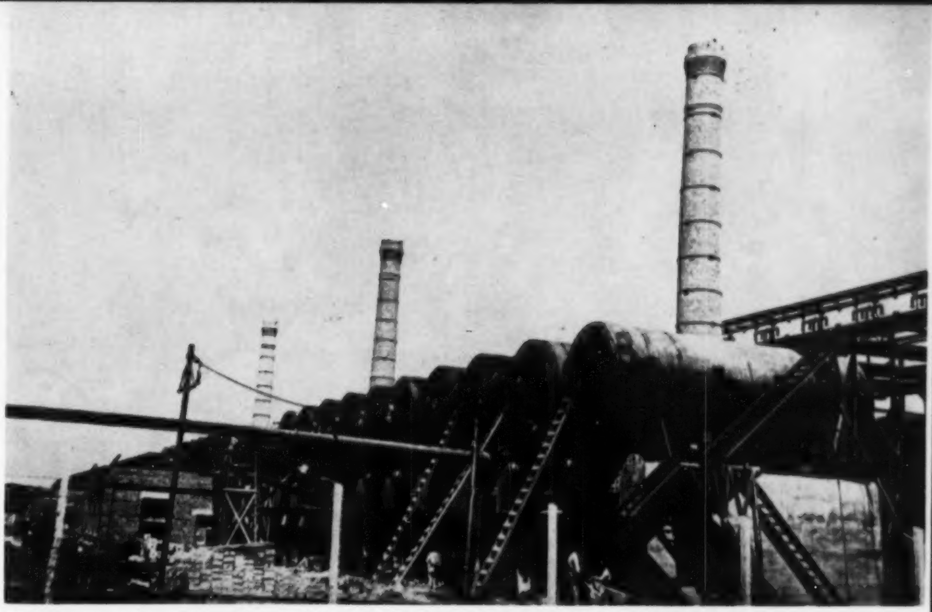
At the time of the decline of the Roman Empire, Pliny the Elder recommended oil for bleeding, cataract, leprosy, gout, toothache, rheumatism, and for straightening eyelashes. The American Indian used oil for healing and lubricating his body. He burned oil in his rituals and used asphalt to waterproof his canoe.

The white man recognized the curative properties of oil and used it not only in the treatment of his own ills but also in the care of sick

The petroleum refinery of today. Spherical gas storage tanks and fluid catalytic cracker at Humble Oil and Refining Company's Baytown, Texas refinery.

and injured horses and other domestic animals. He used it as an insect repellant and lubricated machinery with it. However it was not until the Twentieth Century that man saw in oil a potential source of energy which could be made to do useful work.

By 1800 men were searching for an improved way to get light. The demand for whale oil and tallow candles had become far greater than the supply. In 1826, Dr. S. P. Hildreth of Marietta, Ohio, wrote: "Petroleum affords considerable profit and is beginning to be in demand for lamps and work shops and manufactories. It affords a clear, brisk light when burnt this way and will be a valuable article for lighting the street lamps in the future cities of Ohio."



High-pressure thermal cracking stills (1917). Heavy oil was charged to the horizontal drums and heated after which vapors from the drum were condensed as product. After a run, men entered the tanks and dug out the residual coke.

A Scotsman, James Young, distilled oil from coal and shale in 1847. About 1854, a Canadian geologist, Dr. Abraham Gesner, developed an improved coal oil for lamps and called it "kerosene."

Up until 1859 all petroleum had been skimmed from streams where it collected after seeping through the ground. However, most petroleum is sealed off by impervious rocks and only rarely reaches the surface without help from man. In 1859 the first oil well was drilled. Before this, oil had been encountered in drilling for salt. When in 1829, near Burkesville, Kentucky, saltwell drillers encountered an oil gusher, they permitted it to pour into the Cumberland River. Other salt wells were occasionally reported ruined by the presence of oil.

The first man to make real money from petroleum got his oil by collecting it from the surface of brine from a salt well operated by his father. This man was Samuel Kier, a Pittsburgh druggist. He marketed his oil in bottles for medicinal purposes, calling it "Kier's Rock Oil."

Some of Kier's oil fell into the hands of a New York kerosene dealer, Colonel A. C. Ferris. Ferris had been selling kerosene made from coal and shale and decided to try marketing the new petroleum oil around New York City. He sold it but the customers complained. In spite of Kier's crude attempts at refining, the oil did not burn well and had a nauseating odor. This started Ferris experimenting and he found that by treating the oil first with acid and then with hot caustic, the odor was eleminated. Soon Ferris' customers demanded more refined oil than he could supply. The price jumped from 75 cents per gallon to $1.50 and $2.00.

At this price there was a big incentive to go out and find more petroleum. All efforts, however, to increase the supply met with indifferent success until 1859.

The First Well

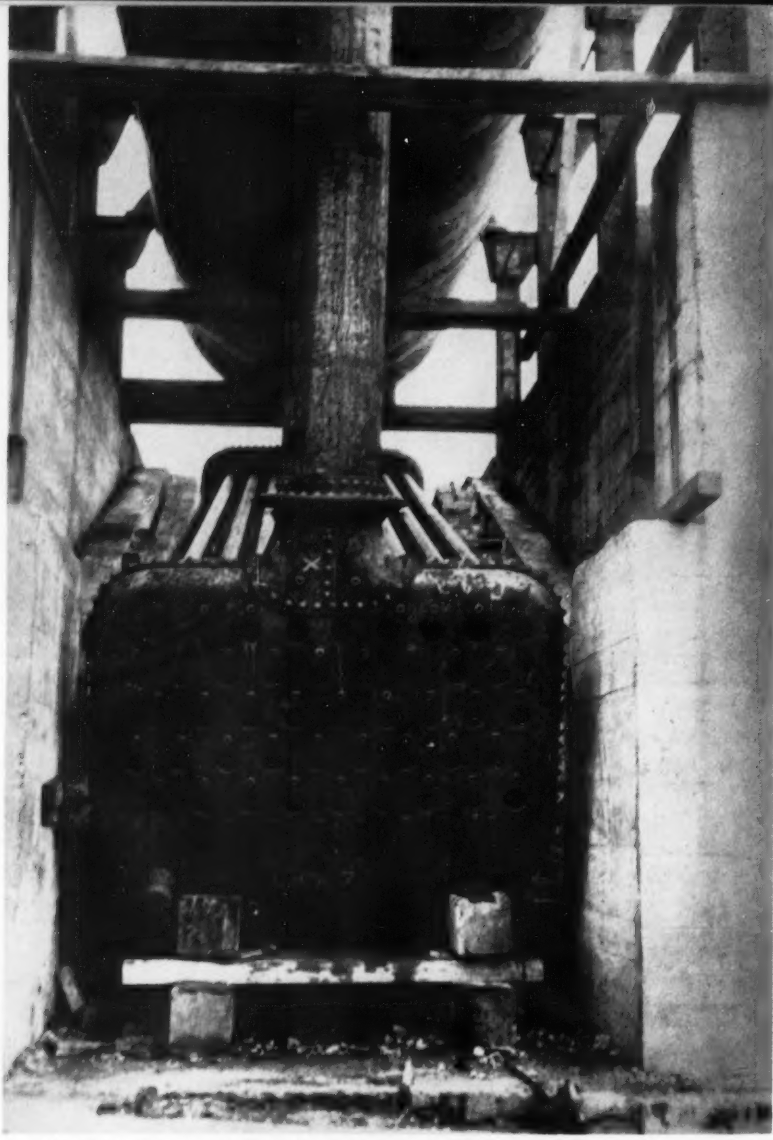
The story of the first oil well begins when George H. Bissel, a business man of New Haven, saw a sample of Pennsylvania oil and became so interested that he traveled to Titusville, Pennsylvania with J. G. Eveleth, his partner. Together they acquired what was considered the most promising oil land in Pennsylvania. Bissel and Eveleth organized the Pennsylvania Rock Oil Company—the first petroleum company in the United States. The company recovered oil from seepages and sold it for $1.50 a gallon. In 1855, they hired Professor Benjamin Silliman, Jr. of Yale to analyze their oil and find more extensive uses for it. He concluded that a useful kerosene or synthetic coal oil and a number of other products could be refined from the crude petroleum. He wrote: "It appears to me that there is much ground for encouragement in the belief that your company have in their possession a raw material from which, by simple and not expensive process, they may manufacture very valuable products."

About 1857 Bissel saw a sign advertising Kier's Rock Oil in a drug store window while strolling down Broadway in New York City. The sign showed one of the derricks used for boring and pumping brine wells. An idea struck him—*drill* for oil. Bissel talked to his partner and it was decided to drill for oil near Titusville. Edwin L. Drake, a retired railroad conductor, was picked to go out and investigate the oil property largely because he could get a free pass on the Pennsylvania Railroad. As is now well known, Drake struck oil in 1859, starting the fabulous oil rush in Pennsylvania.

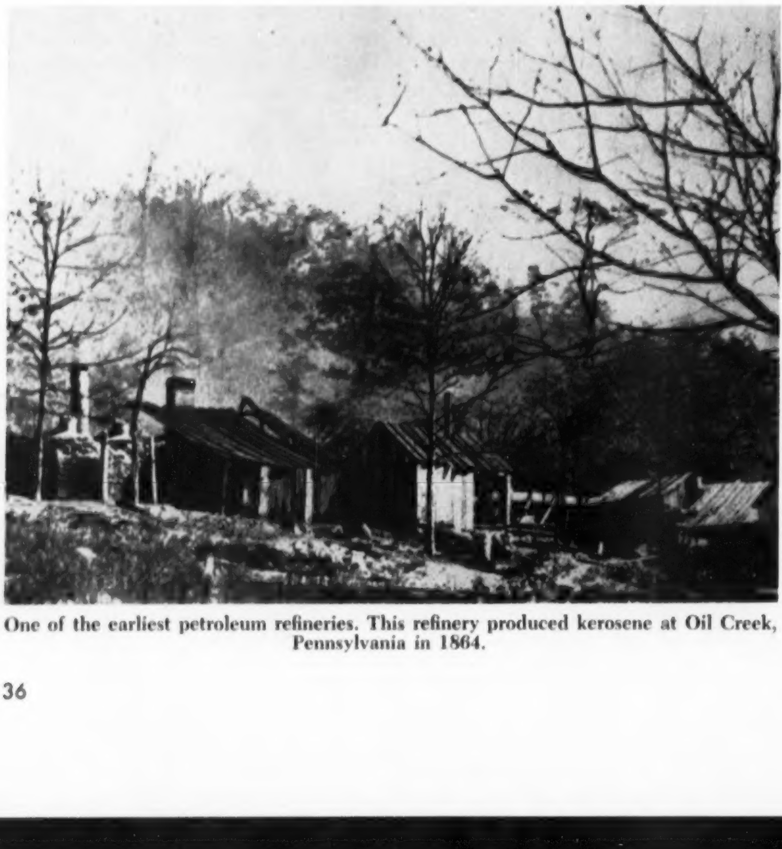
When Drake's well began producing he was pumping from eight to ten barrels per day. Immediately he arranged to sell some of his oil to Kier and others who also sold oil for medicinal purposes. But a surplus remained for which there was no market. Like Colonel Ferris, Drake learned that the oil would have to be purified before it could be burned in lamps.

And Then Refineries

As more wells sprang up near Drake's original one, little refineries mushroomed to meet this need for purification. Fifteen were in operation by the end of 1860. The coal oil industry was thrown into confusion by the discovery of oil in Pennsylvania, and within a



The fire-tube boiler of a high-pressure thermal cracking still. The boiler shown is under the cylindrical cracking drum.



One of the earliest petroleum refineries. This refinery produced kerosene at Oil Creek, Pennsylvania in 1864.

few years most of the coal-distillation plants had been adapted to the processing of petroleum.

The refining process was simple. Crude oil was pumped into an iron drum, and heated with a coal fire. As the oil evaporated, the vapor passed from the still to a coil in which it was condensed. Then the liquid ran into receiving tanks or vats.

The first product to come off was naphtha. Next came lamp oil, and finally a heavy oil containing paraffin. The residue from the still was dumped into a river or creek or burned as worthless. Thirty to forty barrels of crude oil out of every 100 distilled were wasted.

The lamp oil was conveyed to a tank or agitator where it was treated with sulfuric acid to eliminate impurities. Next it was washed, treated with a hot solution of caustic soda and drained off into settling tubs to allow the gaseous portions to evaporate.

When the process was complete, the oil was barreled and ready for marketing. In spite of the strenuous objections of the people who made kerosene from coal and shale, the name kerosene was quickly adopted by the petroleum refiners for their main product.

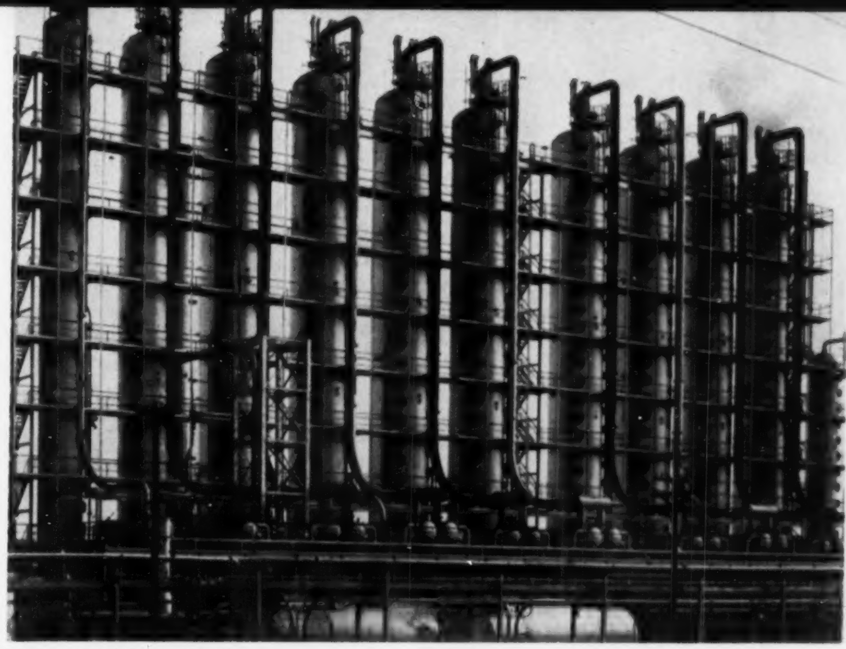
Five hundred thousand barrels of crude were produced in 1860 at an average price of $9.60 per barrel. The next year production jumped to over two million barrels, and the bottom dropped out of the market. That year the average price sank to 49 cents with some crude selling for as low as ten cents a barrel. There was too much crude without refining capacity to process it and no adequate transportation facilities to get it to existing refineries or to the populous marketing areas.

Although at the outset refining capacity was chiefly in the coal-oil refineries, it was not long before the petroleum industry began to erect its own refineries. The principal refining centers were: Pittsburgh and other locations adjacent to production; Cleveland, whose access to lake transportation linked it by water to both the eastern and midwestern markets; and New York, Philadelphia, and Baltimore with their deep-water ports looking toward the markets of Europe.

The transition from coal oil to

petroleum as the principal source of kerosene was rapid. The development of lubricating oils from petroleum came more slowly, however, since product quality was limited by the technology of the day, and industry had to be convinced that the new lubricating oil was superior to those in use. Gradually, however, as oil men learned more about manufacturing lube oils, as quality improved, industries, led by the railroads, began to accept petroleum lubricants as the answer to their lubrication problems.

By 1863, sixty-one refineries dotted the oil region of Pennsylvania with capacities varying from 15 to 400 barrels per day. For more than forty years after the drilling of the Drake well, most of the refining was done in that vicinity, in Ohio, and along the Atlantic seaboard. Refiners continued to use the old methods.



Modern bubble-cap distillation towers. Compare these units with the batch stills of the early kerosene refiners.

The Westward Movement

At the turn of the century the oil industry began to develop in the west and southwest. It was on the Gulf Coast that the great Spindletop oil field near Beaumont, Texas, was discovered in January 1901. Anthony F. Lucas, a former Austrian Navy Officer had set up his new rotary drilling rig, called "Spindletop" by the natives, on the Texas plains south of Beaumont. At a depth of 1020 feet the going had become difficult and the rig had been shut down. Length by length the drill pipe had been lifted from the hole so the worn bit could be replaced. The tools were being lowered again when, totally unexpected, the world's now best-known gusher came roaring in, sending a plume of oil 200 feet into the air. The well appeared to be "good for 100,000 barrels a day" and literally spilled a lake of oil over the countryside before it could be brought under control. Thus was born Lucas No. 1—the well that established the state of Texas as a major oil source.

Spindletop was the most spectacular oil discovery that had been made up to that time. From Spindletop on, the U. S. oil industry has grown rapidly and steadily until it has reached its present stature and importance to our nation's economy. Before Spindletop there was not enough oil to make our present machine age possible; after Spindletop, discoveries followed frequently and in sufficient volume to provide amply for an ever increasing number of machines and transportation vehicles.

Industrial Giant

From 1900 to 1930, the refining industry climbed from a modest position to become the fourth largest in the country. During that period it converted from a simple distillation procedure to a truly manufacturing one. This changeover was essential because of the growth of the automobile and the consequent demand for gasoline. Before the advent of the automobile, petroleum was refined in order to produce a fuel for lamps. This fuel was kerosene; when properly prepared it would burn on a wick but not ignite by itself when in contact with a flame. Since the low-boiling constituents of petroleum were of little value there was always the temptation to prepare a kerosene with such a high percentage of volatile components that it would ignite with a free flame and thus constitute a fire hazard. Laws were enacted limiting the gasoline content of kerosene.

After the introduction of the motor car, the situation was soon reversed. Gasoline, not kerosene, was in great demand. By 1915 the United States was importing gasoline to help meet domestic demand, which was about seven times as great as it had been in 1900.

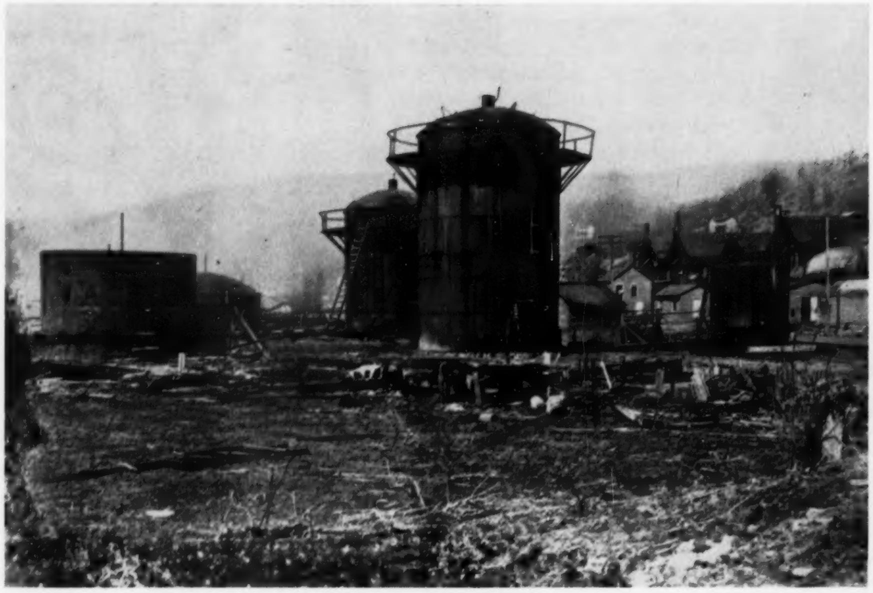
The petroleum chemist went to work to devise methods by which gasoline could be manufactured synthetically from heavy fractions of crude oil which otherwise could not be used as motor fuel. The answer was found in various thermal cracking processes, the first of which was introduced in 1913. It was discovered that at high temperatures and pressures, hydrocarbons in the heavier fractions could be cracked into the lighter molecules which are constituents of gasoline.

The Cracking Process

Cracking is reported to have been discovered accidentally in 1861. A distillation in a 16-barrel still had been half completed, and the stillman had built a strong fire. The stillman intended to be away an hour but was unable to return until four hours later. He found that a light-colored distillate of a low specific gravity was being collected. The specific gravity was even lower than that of the product before he left. Upon investigation, it was found that a heavy oil was condensing on cooler parts of the equipment and dropping back into parts of the still which were at a temperature sufficiently high to cause decomposition of the heavy oil into lower boiling products.

In 1913 William Burton was granted a patent on his famous cracking process. The Standard Oil Company of Indiana was the first to use it. The early Burton cracking stills were horizontal tanks eight feet in diameter and twenty feet

long, made of ½-inch mild steel. A heavy oil was charged to the drum which was coal fired. The oil was heated to a temperature of 750° F for about 48 hours. The pressure was maintained between 75 and 95 pounds per square inch. The vapors from the tank were condensed as product. After a run the tank was full of coke, produced by break down of the hydrocarbons. This coke was removed by men who entered the tank and dug it out by hand. A total of 1200 of these stills were in use as late as 1928 but after this they were gradually replaced by modern cracking processes.



Crude stills (background, right) and storage tanks at an early refinery near the first oil well at Titusville, Pennsylvania. When this picture was made in 1885, kerosene was the refinery's principal product and gasoline was discarded.

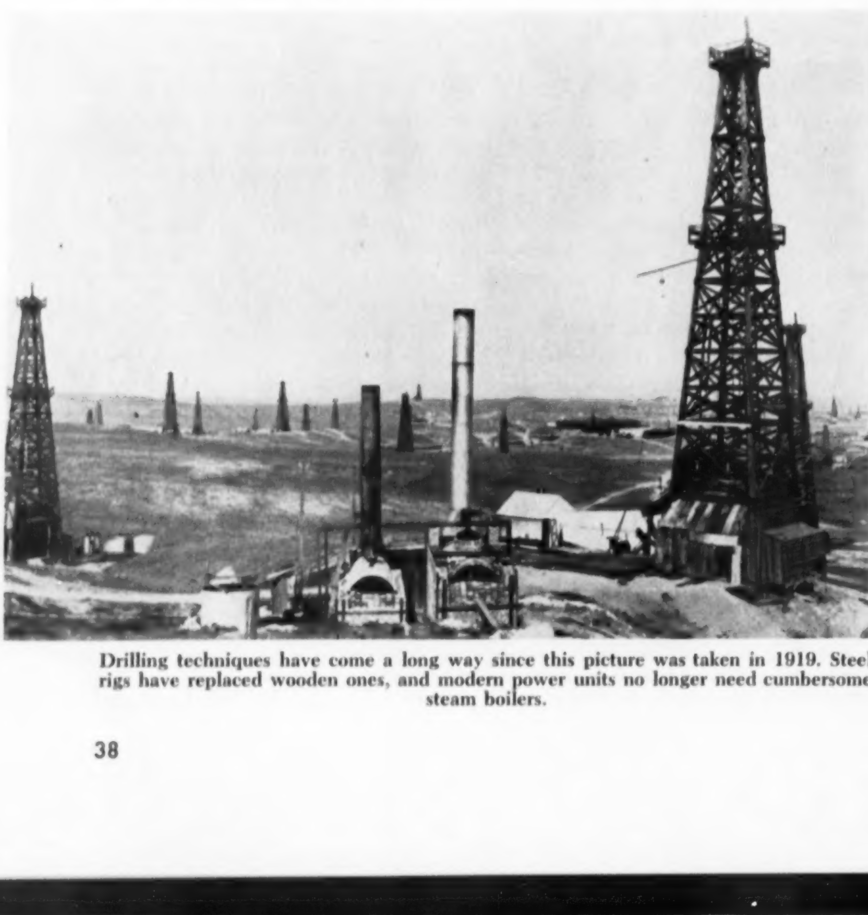
Distillation Improvements

While the various cracking processes were being developed, improvements were being made in methods of distillation. Continuous distillation processes for petroleum refining came into use around 1885. Shell-type stills were placed stepwise in batteries, and accommodated 5000 barrels per day. Crude was pumped into the highest still and the vapor from it was condensed into light gasoline. Then the residue would overflow into the second still and so on down the line. Various "cuts" or products were taken from each still, then redistilled to meet marketing standards. Redistilling operations were conducted in the presence of steam to lower the boiling points of the material.

The first major improvement on this method was made by Trumble, who introduced the pipe still, which allowed a tremendous increase in unit capacity. In 1915 the first Trumble distillation units were built at Shell's Martinez and Coalinga Refineries. The units, being unusually compact, represented a considerable reduction in the cost of refinery equipment. In addition they were able to make a sharper separation between kerosene and gasoline—an important development in an industry facing a wartime demand for gasoline.

Later fractionating towers were mounted over steam stills and reduced the expense of the redistillation process. Another significant technological advance was the bubble tower which aided in fractionation.

Today distillation is only the starting point in petroleum refining. After the initial distillation of the crude, each fraction of "cut" is subjected to a number of processes such as cracking, alkylation, polymerization, reforming, isomerization, hydrogenation, or solvent refining. Thermal cracking has been almost entirely replaced by catalytic cracking. In addition to fuels and lubricants the petroleum industry is producing many organic chemicals from petroleum and natural gas which are sold to the chemical industry as raw materials. Today's petroleum refinery is a far cry from the simple batch stills of the coal-oil refiners. From the beginning, the petroleum industry has been the working partner of machine progress, especially the progress symbolized by the automobile. There is every reason to believe that it will continue to be so.



Drilling techniques have come a long way since this picture was taken in 1919. Steel rigs have replaced wooden ones, and modern power units no longer need cumbersome steam boilers.

MECHANICAL ENGINEERS

CLASS OF 1957

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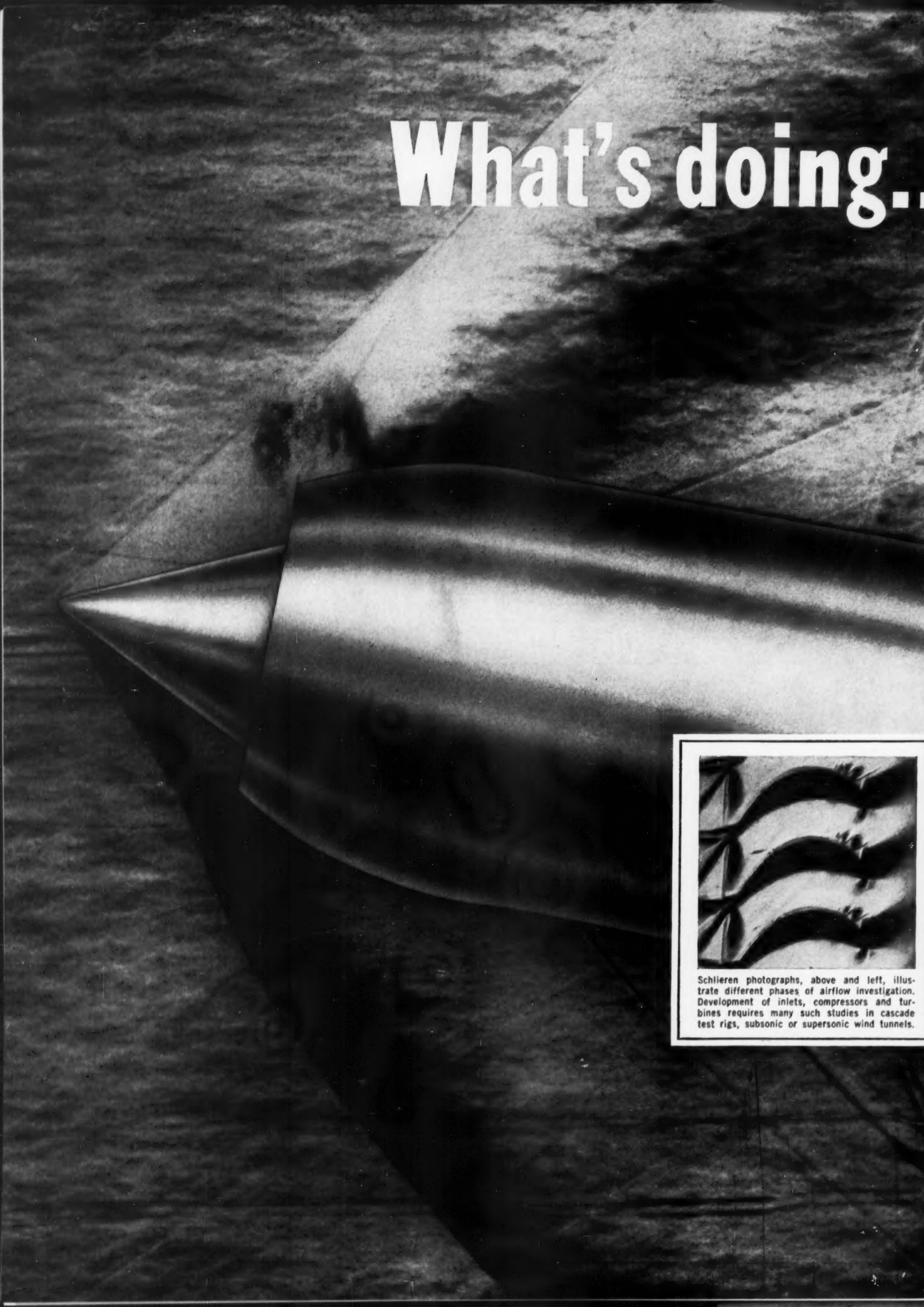
What's doing...



Schlieren photographs, above and left, illustrate different phases of airflow investigation. Development of inlets, compressors and turbines requires many such studies in cascade test rigs, subsonic or supersonic wind tunnels.

. . . at Pratt & Whitney Aircraft in the field of Aerodynamics

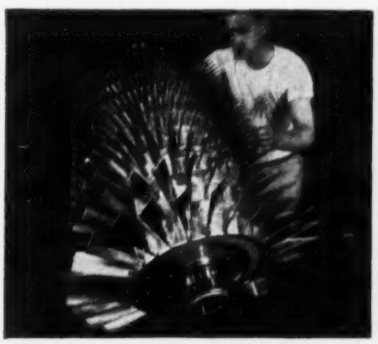
Although each successive chapter in the history of aircraft engines has assigned new and greater importance to the problems of aerodynamics, perhaps the most significant developments came with the dawn of the jet age. Today, aerodynamics is one of the primary factors influencing design and performance of an aircraft powerplant. It follows, then, that Pratt & Whitney Aircraft — world's foremost designer and builder of aircraft engines — is as active in the broad field of aerodynamics as any such company *could* be.

Although the work is demanding, by its very nature it offers virtually unlimited opportunity for the aerodynamicist at P & W A. He deals with airflow conditions in the engine inlet, compressor, burner, turbine and afterburner. From both the theoretical and applied viewpoints, he is engrossed in the problems of perfect, viscous and compressible flow. Problems concerning boundary layers, diffusion, transonic flow, shock waves, jet and wake phenomena, airfoil theory, flutter and stall propagation — all must be attacked through profound theoretical and detailed experimental processes. Adding further to the challenge and complexity of these assignments at P & W A is this fact: the engines developed must ultimately perform in varieties of aircraft ranging from supersonic fighters to intercontinental bombers and transports, functioning throughout a wide range of operational conditions for each type.

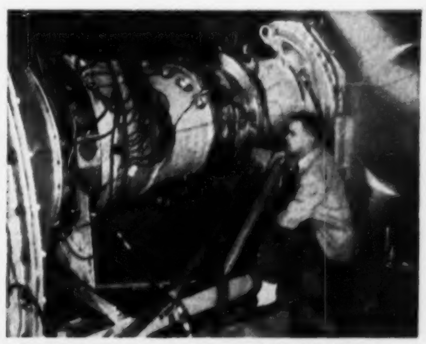
Moreover, since every aircraft is literally designed around a powerplant, the aerodynamicist must continually project his thinking in such a way as to anticipate the timely application of tomorrow's engines to tomorrow's airframes. At his service are one of industry's foremost computing laboratories and the finest experimental facilities.

Aerodynamics, of course, is only one part of a broadly diversified engineering program at Pratt & Whitney Aircraft. That program — with other far-reaching activities in the fields of instrumentation, combustion, materials problems and mechanical design — spells out a gratifying future for many of today's engineering students.

Modern electronic computers accelerate both the analysis and the solution of aerodynamic problems. Some of these problems include studies of airplane performance which permit evaluation of engine-to-airframe applications.



Design of a multi-stage, axial-flow compressor involves some of the most complex problems in the entire field of aerodynamics. The work of aerodynamicists ultimately determines those aspects of blade and total rotor design that are crucial.



Mounting a compressor in a special high-altitude test chamber in P & W A's Willgoos Turbine Laboratory permits study of a variety of performance problems that may be encountered during later development stages.

World's foremost designer and builder of aircraft engines

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CAREERS WITH BECHTEL

PORTER THOMPSON, *Assistant Chief Engineer, Refinery Division*

MECHANICAL ENGINEERING

One of a series of interviews in which Bechtel Corporation executives discuss career opportunities for college men.

QUESTION: *Mr. Thompson, some engineering graduates seem to believe their first jobs might include little more than filing papers. Would that be true at Bechtel?*

THOMPSON: It would not. When the young man joins the Refinery Division, if he is a structural engineer he starts immediately to do structural design work, under proper supervision. An electrical engineer would join our electrical group, working on electrical systems for refineries, doing some design work, taking off materials and working on instrumentation.

QUESTION: *What about mechanical engineers?*

THOMPSON: Mechanical and chemical engineers may either go right into the process department, where they would do calculations, or into the project group where they would do routine designing and write specifications for pumps, exchangers, vessels, piping, instrumentation, insulation, etc.

QUESTION: *There's certainly no sign of "paper shuffling," is there?*

THOMPSON: No. The training period is interesting right from the start. After a few months, we like to send the young engineer out into the field so he can see the end result of what he has been doing.

QUESTION: *What has been your experience as to the length of time required to train a man?*

THOMPSON: That will vary according to the man, so it's impossible to generalize. The young man will have some responsibility right from the start, but it may well be a matter of several years before he can actually take full responsibility for running a job.

QUESTION: *Assuming he handles his first assignments satisfactorily, what would be his first major step upward?*

THOMPSON: After from 6 to 9 months his first responsible assignment might be on a project in connection with handling pumps. On his next project assignment he might have the responsibility for handling pumps and exchangers. He would likely be assigned some other responsibility on each succeeding project. In that way he would get a good grasp of all types of work and eventually be capable of taking overall charge of a project.

QUESTION: *Suppose he is in the structural phase; would there be any difference in his "basic training"?*

THOMPSON: No. He would still have to serve his apprenticeship, moving gradually into more and more complex design work as he gains, a little at a time, the knowledge and experience which qualify him to handle the overall job.

Bechtel Corporation (and its Bechtel foreign subsidiaries) designs, engineers and constructs petroleum refineries, petrochemical and chemical plants; thermal, hydro and nuclear electric generating plants; pipelines for oil and natural gas transmission. Its large and diversified engineering organization offers opportunities for careers in many branches and specialties of engineering —Mechanical...Electrical...Structural ...Chemical...Hydraulic.

Write for new brochures showing the wide variety of projects Bechtel builds throughout the world.

Address: John F. O'Connell,
Vice President, Industrial Relations
220 Bush Street, San Francisco 4, Calif.

BECHTEL CORPORATION

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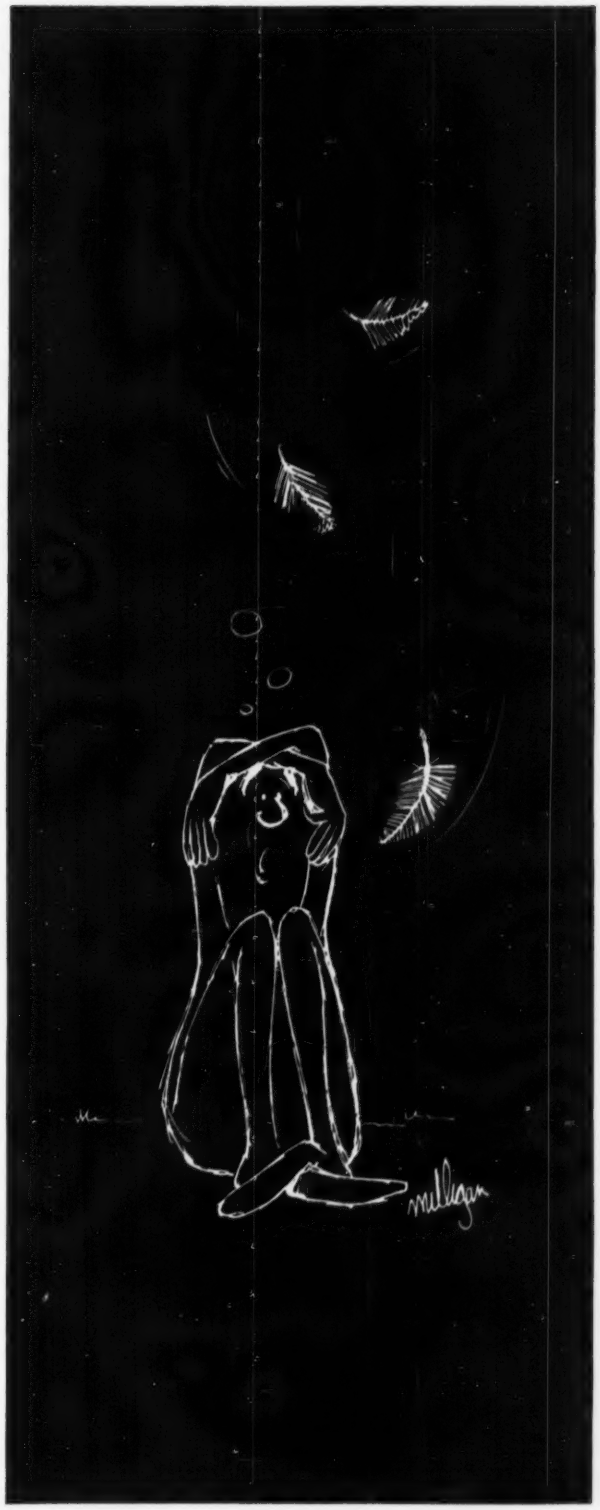
Birds of Extinction



Grumman's homing "birds" become violently extinct when they reach home in the proximity of an enemy aircraft, poor thing. If you're a "bird" hatching type, Grumman's Missile Department may be just the incubator you need.

If your distinction is otherwise, Grumman projects include high Mach jets, STOL's and VTOL's, and hydrofoil amphibians and boats. You name it, we'll talk.

Write Mr. A. T. Wilder,
Engineering Personnel Director.

GRUMMAN AIRCRAFT ENGINEERING CORPORATION

BETHPAGE • LONG ISLAND • NEW YORK

Designers and builders of the supersonic F11F-1 Tiger, transonic F9F-8 Cougar jet fighter, F9F-8T Cougar fighter-trainer, F9F-8P Cougar photo-reconnaissance, S2F anti-submarine Tracker, SA-16 Albatross rescue amphibian, metal boats, and Aerobilt Truck Bodies.

MACHINES THAT ARE HUMAN

by
Lawrence D. Phillips, EE '57

Science fiction writers are continually intrigued with the possibility of duplicating, by electromechanical means, human actions. Although "Robby" the robot in the recent movie, "Forbidden Planet", won no academy award, he exhibited amazingly human characteristics. However, this idea does not belong solely to the realm of science fiction. Actual attempts to construct these human counterparts have met with varying degrees of success; the more notable of these "animals" will be discussed here.

Since his primitive beginning man has been concerned with images. The images of the cave man, crudely sketched on cave walls, effigies of offending tribesmen into which pins were (and still are) hopefully stuck, the figurehead constantly surveying the horizon from the prow of a ship, the revered idols of pagan worshippers, the clockwork automata of Swiss watchmakers aptly illustrate man's varying interest for the making of images. When the concept of feedback was discovered, man learned to turn his toys to tools in the form of self-regulating devices. And the introduction of the vacuum tube made possible the imitation of a reflex circuit.

Duplication of external form and behavior in a stereotyped manner characterized initial attempts to imitate life. The mechanical villages at the State Fair, the nimble Santa Claus and all his helpers industriously performing the same motions over and over in the department store window are far removed from scientific imitations of life.

Theseus

The mechanical mouse, *Theseus,* built by Claude Shannon of Bell Laboratories, reveals a remarkable memory. Once the mouse has learned, by trial-and-error, to find his way out of the maze, he can repeat the performance with no mistakes. But, unlike a real mouse, his behavior is restricted and always predictable.

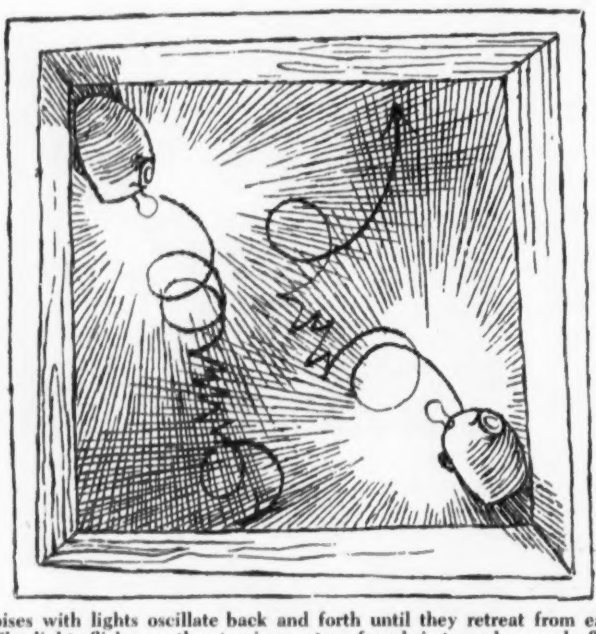
You can't beat the tic-tac-toe machine constructed by guided-missiles engineer Edward McCormick, another example of the ability of a machine to "think". But again, the thinking is stereotyped and predictable.

For a model to be a reasonable imitation of cerebral activity, it must copy not looks, but action. Stimulus-response situations must be similar to those of a real animal. This would require the model to exhibit some or all of the qualities of association of ideas, learning, forgetting, frustration, goal orientation, homeostasis, intelligence, locomotion, memory, perception, self-recognition, free-will in the sense of unpredictability, choice, and behavior resulting from drive states (such as hunger and exploratory drives).

This rules out the unlifelike creations mentioned thus far, for none adequately represent the human manifestations of the above qualities. Even *Theseus* is very unlike a real mouse, for while he does have a memory, it is a machine memory which doesn't forget, needs no reinforcement, and learns on the first trial. Human memory is fallible, variable and reinforceable in subtle ways.

This also eliminates the modern "giant brains", digital and analog computers, with all their myriad programming combinations.

Variety of programming can not endow a machine with true life-like qualities.

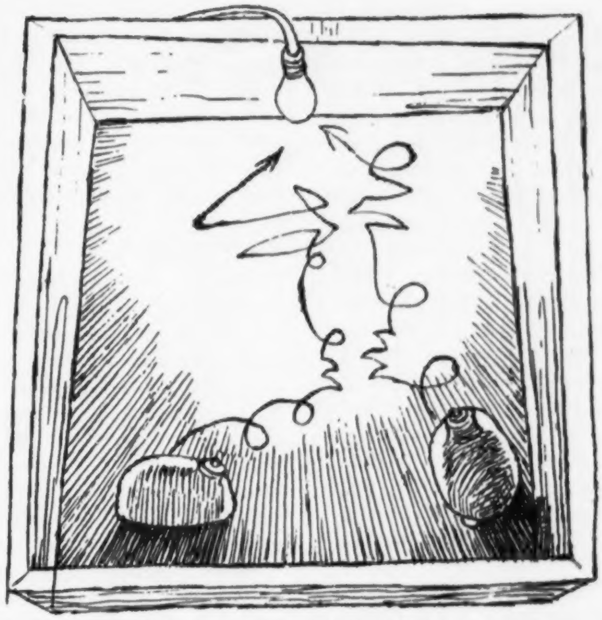


Two tortoises with lights oscillate back and forth until they retreat from each other. The lights flicker as the steering motor of each is turned on and off.

Ashby's Homeostat

What, then, does this leave us? Strangely, fewer than half a dozen machines have been built which

really can claim to mimic life, or, at most, a few aspects of life. One of these is Ashby's homeostat. As is implied by the name, this is essentially a self-regulating machine employing negative feedback, in fact, it is all feedback. It consists of four units; four magnets, one on top of each unit, represent the main variables. Any displacement of one or more of the magnets causes the machine to pick the correct circuit out of 390,625 possible circuit combinations to bring the machine back to a state of dynamic internal stability. The homeostat is impressively unpredictable in that it is impossible to tell which circuit is activated without "killing" the machine and tracing out the wires to the relays. The device could be likened to a dog or cat which comfortably curls up beside the fireplace to nap, only moving to a more comfortable spot when it is kicked. But unlike an animal, all it does is "sleep" and seek the most "comfortable" position. Thus, it has a predestined end, but an unpredictable way of reaching it.



Two tortoises without lights head toward a single light in a jostling manner. When their shells come into contact they briefly back away from each other.

Timothy Turtle

Another creature, a more lifelike image, is *Timothy*, a robot electronic turtle created by Jack Kubanoff. *Timothy* was originally built as a child's toy, but nevertheless he exhibits several "human" properties: he sees with his photo-cell eyes, interprets information in the form of a pulsating light, follows instructions, thinks (insofar as he can choose between different types of light information), searches for food, memorizes and learns.

When *Timothy* is in a drive state of "hunger", he will search for food, in the form of a light flashing at a certain rate, and he will turn away from any other kind of light information. If the rate of flashing changes he will learn the new word for food. Removal of the flashing light does not deter him from his course, for he can remember the location of the light before it was extinguished. When he reaches the source of "food" he will "eat" (his capacitors will charge) enough for one-half hour of playing time. Now he will follow a steady light, the "play" signal, for a period determined by the discharge time of a capacitor circuit. During this time he will ignore food and will memorize the position of the "play" light if it is hidden from him.

Timothy has two memories—one remembers one word at a time permanently (the code word for food) and the other remembers position temporarily. Like human memories, both require repetition to learn. His permanent memory will remember over a long time even with short, rare activation periods and long deactivation periods. However, the turtle will become confused if the code word is changed faster than he can learn. The parallels between Timothy's learning the word for food and the animal learning process are obvious.

Machina Speculatrix

An electro-mechanical creature which is considerably simpler than *Timothy* and which responds more nearly to stimuli as they actually exist in the physical world is the creation of a famed British physiologist, W. Grey Walter. His creation, *Machina Speculatrix*, is a three-wheeled animal that responds to light and touch. This is accomplished through two nerve cells consisting of two small electric motors, two relays, two capacitors, two resistors, two miniature tubes and two batteries. The nerve cells, or "sense reflexes", are activated by two "receptors" consisting of a photoelectric cell for an eye and a shell contact switch for a touch receptor.

This "receptor-effector" circuit is capable of imitating many of the basic modes of behavior of simple living creatures. Unlike Ashby's homeostat, *M. Speculatrix* is continually exploring his environment, except when "feeding". It scurries around in small sweeping curves and will investigate several hundred square feet of ground in an hour.

The one positive tropism exhibited by *M. Speculatrix* is an affinity for light of moderate intensity. His photo-cell, amplifier and motors are connected so that exploratory behavior ceases when an adequate light signal is seen, and the animal heads for the light. Avoiding the fate of the moth that burns to death in the candle flame, *M. Speculatrix* exhibits a negative tropism for very bright light. Steep gradients and material objects are repellant to the device, also.

Whenever a material object is met, *M. Speculatrix* adopts two forms of escape almost simultaneously. When he bumps into something, closing the contact switch attached to his turtle-like shell, his photo-amplifier is converted to an oscillator. This causes the animal to alternately push and withdraw. Thus, if the object is small, it will be pushed out of the way; if it is

large, *M. Speculatrix* will go around it. If the machine is moving toward a light and runs into an obstacle, the light is temporarily "forgotten" and no longer attracts the animal. A brief "memory" of the obstacle causes the machine to ignore the light for a few seconds after withdrawal from the obstacle.

Inside the machine's "hutch" is a light of moderate intensity, which, of course, acts as a positive stimulus. If the animal, in the course of its wanderings, is led to the "hutch", a repelling circuit at the threshold causes the animal to retreat if its batteries are fully charged. However, if the batteries require charging, "moderation gives place to appetite" and the animal enters its quarters. There, contacts on the shell and hutch engage and the battery charging circuit automatically closes. When the batteries are fully charged, the charging current falls and the internal mechanism becomes operative. Its hunger satisfied, *M. Speculatrix* once more sallies forth for more adventure.

By now the reader may well ask, "What would be involved in adding another sense modality? *M. Speculatrix* seems unable to learn anything. Could we not add another sense so that the new machine could be conditioned, or taught?" The answer is not so simple, for, although Dr. Walter has constructed such a machine, its capacity to learn involves much more than simply adding another sense.

Applying The Learning Process

Consider for a moment Pavlov's classical experiment in conditioning. Food, the unconditioned adequate stimulus for salivation, was presented to a dog just following the ringing of a bell, a neutral stimulus. After repeating this procedure many times, some connection between the bell and salivation was established so that subsequent ringing of the bell elicited salivation without presentation of food. Thus, the bell became a conditioned stimulus for salivation. This can be represented by:

$$\left.\begin{array}{l}\text{Bell}\\\text{Food}\end{array}\right\}\text{Salivation}$$

Dr. Walter's job was to design a Conditioned Reflex Analog which would duplicate, in effect, Pavlov's results. The problem is illustrated in Figure 1. The unconditioned stimulus, U.S., elicits the specific response, R_s, by means of the reflex circuit, R_1. The stimulus to be conditioned, C. S., may elicit a neutral response, R_n, (such as pricking of the ears, in Pavlov's experiment) through R_2. During conditioning, some link is established through the Black Box of learning, X, such that the presentation of the conditioned stimulus will eventually result in the specific response, but not necessarily the neutral response. Our problem is, what is in the Learning Box between the two reflexes?

Dr. Walter's experiments finally reduced the electronic learning process to seven steps. Here is what the black box accomplishes: (Numbers correspond to the numbered sections in Figure 2 which carry out the appropriate actions.)

(1). Synaptic transmission occurs for a neutral stimulus of sufficient strength and is "remembered" or stretched out. This is done so that the stimulus will have a prolonged effect, lasting at least to the presentation of food.

(2). Synaptic transmission occurs only at the presentation of the adequate stimulus, food. This ensures that a neutral stimulus which might occur during dinner would

Moderation gives place to appetite as *Speculatrix* finds her way home.

not become a conditioned stimulus to *mean* dinner.

(3). To determine if the two stimuli are significantly related, the signals from (1) and (2) are mixed, i.e., their areas are added, at the neurone.

(4). If they are related, they will overlap (electrically), and the area of coincidence must be added to the area of coincidence from the last similar conditioning trial.

(5). If the conditioning trials have been sufficient in number, and if the neutral and adequate stimuli were sufficiently closely related in time, the added areas of coincidence will become great enough to trigger a neurone. This triggering occurs only when (4) reaches a specified threshold. This threshold is determined by a statistical analysis of the conditioning process. More modern conditioning theories would necessitate a sort of roulette wheel for the device at (4), but the simpler method of using a capacitor to sum the overlapping areas of the mixed signals is a close approximation.

(6). The trigger pulse from (5) causes the closed circuit to oscillate. This serves as a memory for the animal, but unless the conditioning is reinforced the oscillations will slowly die out and the animal will forget the areas of coincidence after a time.

(7). A mixing neurone discharges only when signals from (6) and the C.S. are present. Thus, when conditioning is complete, presentation of the conditioned stimulus will elicit the specific response. An inhibitor, (8), blocks the action of the neutral response.

Machina Docilis

All this in the Black Box! The addition of another sense has indeed complicated matters, but a new, vastly more interesting animal emerges, *Machina Docilis,* the easily taught machine. Actually, *M. Docilis* is the result of grafting CORA, the Conditioned Reflex Analog, onto *M. Speculatrix*. A sound sensitive circuit was also added.

Our new animal can be conditioned to come to the sound of a whistle. Remembering that *M. Speculatrix* would respond to a light of medium intensity, the following process can take place:

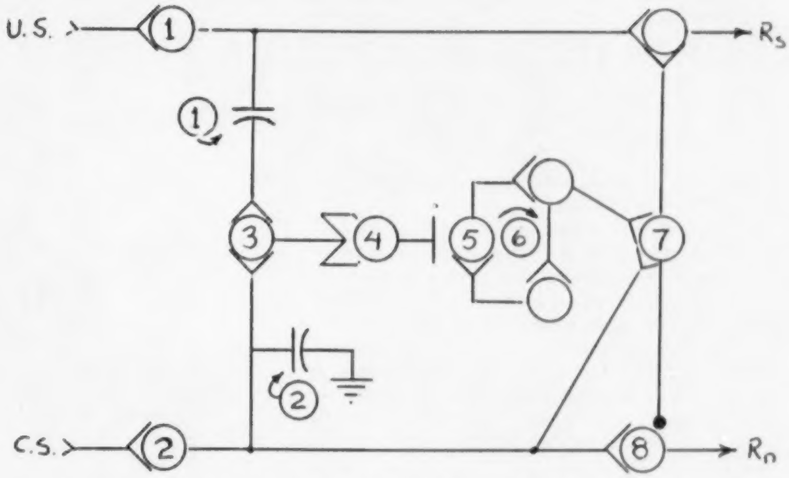


Fig. 2: Contents of the black box of warning.

$$\left.\begin{array}{l}\text{Light}\\ \text{Whistle}\end{array}\right\}\text{“Come”}$$

That is, "whistle-means-light, so come". Just like a real animal, if this is not reinforced occasionally, the response will eventually die out.

Sound can also be made to mean trouble. CORA was connected to the obstacle-avoiding device in *M. Speculatrix*. Consider, then:

$$\left.\begin{array}{l}\text{Whistle}\\ \text{Kick}\end{array}\right\}\text{“Back away”}$$

That is, the whistle was blown and then the animal was kicked. Eventually it learned that "whistle-means-obstacle" and it would back away from an imagined object on hearing the whistle. At this point an unexpected confirmation of actual animal behavior occurred. *Speculatrix* ignores lights when dodging obstacles. This is accomplished by an internal feedback circuit, and this feedback serves to reinforce the above conditioning process in *M. Docilis*. Thus, the defensive reflex does not require any reinforcement, just as in real animals.

A nightmarishly real situation can come about with the addition of another Learning Box (so that all three senses, light, touch and sound, may be utilized) and an extra inhibitory circuit which causes the animal to freeze to sound. The animal can be taught that 1) sound-means-light, so go to sound, 2) light-means-sound, so freeze to light, and, 3) touch-means-sound, so freeze when touched.

Now, if, while we establish the first, or sound-means-light response and then kick the animal while it is moving, it eventually learns that "touch-means-sound, so freeze". But this response is directly opposed to the first process. The result? The animal shivers in a neurotic palsy, unable to move whether kicked, whistled at, or tempted with light. Its hutch no longer attracts it, so it starves in a neurotic depression. And the only sure cure is the dissection of the animal's circuits.

(Continued on Page 64)

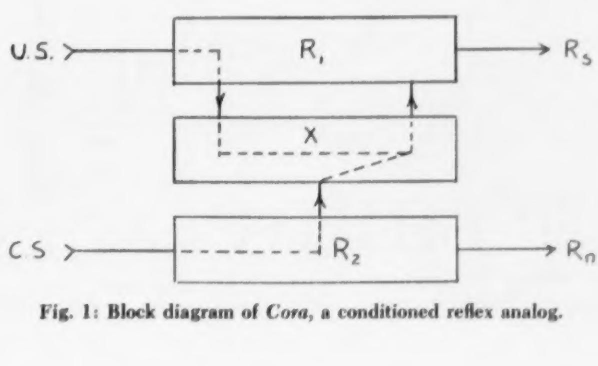


Fig. 1: Block diagram of *Cora*, a conditioned reflex analog.

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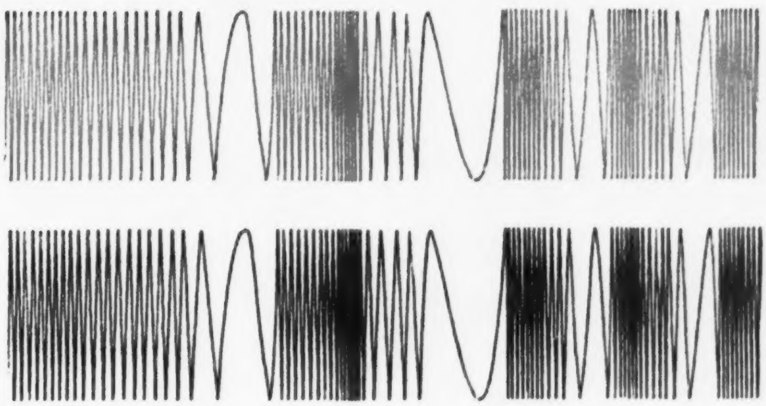
- *odor control*
- *biological grade chemicals*



Ball-point inks

If you drew a continuous, unbroken line with a ball-point pen until its ink supply was exhausted, the line would be two to three miles long. Enough to write 50,000 to 70,000 words, compared with the 2,500 to 4,000 words you get from the same amount of fountain pen ink.

Because you would be exhausted long before your ink supply, a mechanical scriber—which produces those mysterious zig-zag lines above—is used to test hundreds of ball-point ink formulations.

The amazing number of words coming from a ball-point pen has enabled ball-points to roll past both fountain pens and mechanical pencils to become the most commonly used writing instruments today.

This would not be so if the ball-point pen remained unchanged, still staining, skipping, smearing, drying up. A better mechanical tool was needed to start with.

Once accomplished, the ink became the most important element, and synthetic organic chemists turned to the key element—the colorant—which is half of the entire ink formulation.

Early ball-point inks were made with the same dyes used for years in fluid inks. But ball-points have different ink requirements: good flow properties, lubricity, solubility, storage stability and—most important—an exceptionally high concentration of dye. Tinctorial value must be twenty times that of a fluid ink.

From research has come a special line of NATIONAL dyes, tailor-made for ball-point inks. Research on both pen and ink has enabled the ball-point to supplant in 15 years the pointed pen, in use for 13 centuries.

Odor control

Odor control presents an ingenious twist on the old question of whether there is any sound when a tree falls in a deserted forest.

We have always had odor-causing sites. But today, with industry expanding and our suburban communities moving further into the country, these odors become a serious problem. Some sources of this problem are sewage plants, landfill garbage, drainage ditches, storm sewers and market area streets.

SOLVAY OZENE (emulsifiable orthodichlorobenzene) is becoming widely used in industrial odor control situations, for dripping into sewage or spraying on garbage and other odor sources.

OZENE works on odors these ways: its own odor serves as a masking agent; it slows down the production of bacteria which cause sulfide odors; it prevents the growth of fungi which speed the decomposition of waste materials.

A dark-colored liquid, OZENE mixes readily with water and can be substantially diluted for economical use.

Biological grade chemicals

Preparing balanced salt solutions for the growth of cultures is typical of the stringent needs of biochemists for extremely high-purity chemicals, products which have been purified even beyond the universally recognized American Chemical Society quality standards for analytical reagents.

Three such "reagent plus" compounds have been added to BAKER & ADAMSON's line of 1,000 laboratory reagents. These initial chemicals—sodium bicarbonate, sodium chloride and potassium chloride—show very minute trace impurities, materially lower than in similar chemicals produced to A. C. S. specifications.

They are the first in a proposed line of biological grade chemicals made especially for such important scientific applications.

Creative Research

These examples of product development work are illustrative of some of Allied Chemical's research activities and opportunities. Allied divisions offer rewarding careers in many different areas of chemical research and development.

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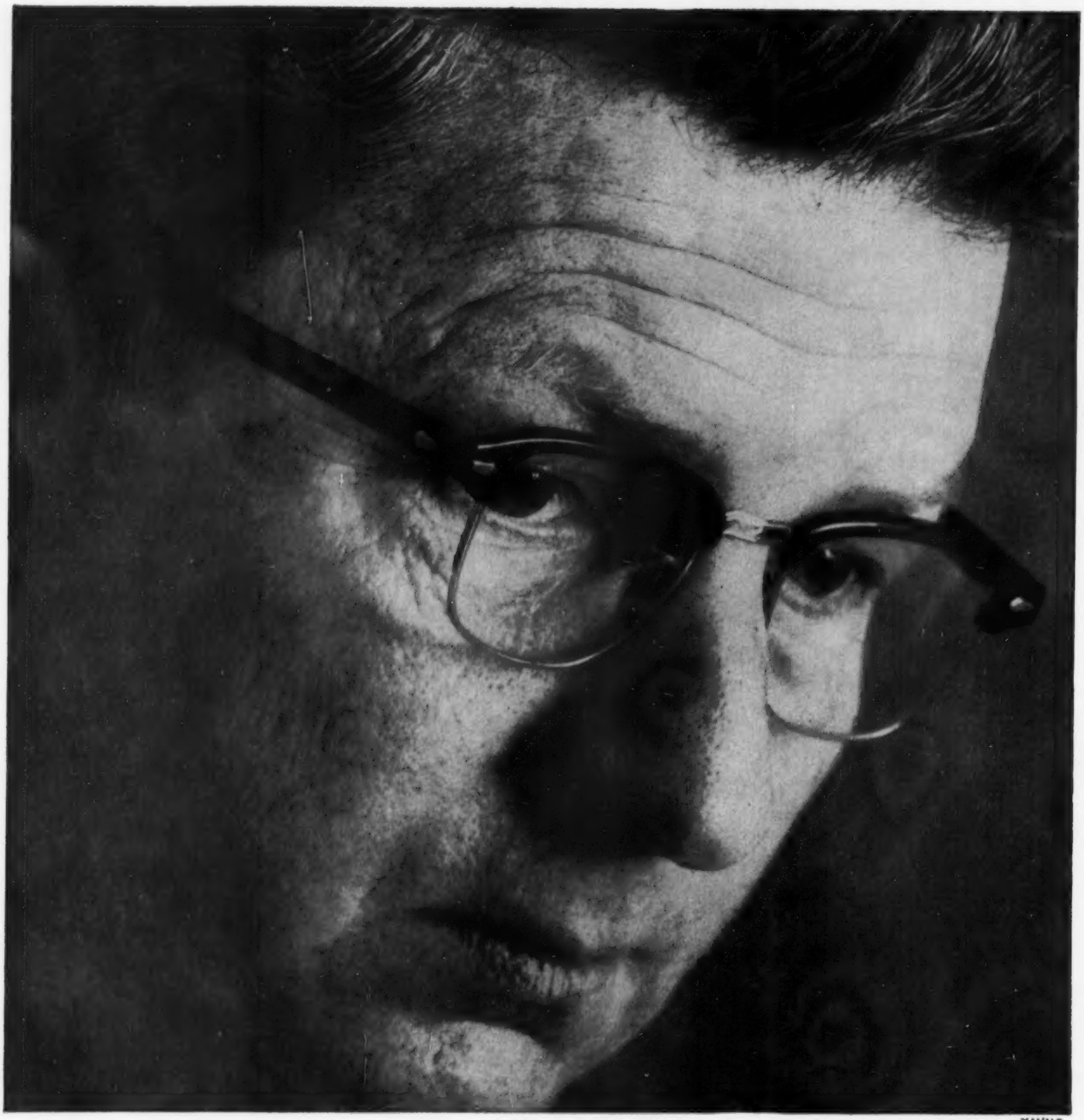

YAVNO

...on economy in national defense

"The widespread belief that there is an inherent conflict of interest between those who put national security first on the one hand and the taxpayer and his cost-conscious representatives on the other is simply erroneous—except when the level of the national security budget is at issue. Once the budget level has been fixed, the choice of weapons which maximizes our military capability is logically equivalent to the choice which minimizes the cost of attaining that capability. Moreover, the weapon characteristics so chosen are typically similar at different budget levels. In these circumstances economy and military effectiveness are not opposing objectives to be compromised; they are different but equivalent aspects of the same national objective."

—*Charles Hitch, Head of the Economics Division*

THE RAND CORPORATION SANTA MONICA, CALIFORNIA
A nonprofit organization engaged in research on problems related to national security and the public interest

Photo courtesy Columbian Apartments, typical of housing available in area.

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TALK SHOP OR SPORTS CARS to Don Carter, and you'll find his keenest interests. At Chance Vought, in Dallas, Don keeps up with both subjects. He's *living* while he's building his professional career. Fun, to Don, means sports car races at nearby Eagle Mountain Lake, or a splash in his swank apartment pool. Fun means *career*, too, because Vought helped Don find a field he thoroughly enjoys – exploring new applications for human engineering in the design of complex electronic gear. Here, Don's electronics training comes in handy, and so would a good grasp of psychology. So Don's working toward an M.A. in Psychology, and Chance Vought's helping with tuition.

Part of Don's assignment is to simplify instrument arrangement in supersonic fighter cockpits. Here he and a Vought psychologist study a problem in human engineering.

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WHY MAGNETIC TAPE RECORDINGS?

by

Gerald F. Dulin, EE '57

In this period of the awakening to hi-fidelity it is rather strange that magnetic recording has not really come into its own. Tape recording, in particular, has a number of outstanding advantages over other conventional forms of sound recording.

Slow Recognition

The consumer's rather slow acceptance of magnetic recording can be traced to several historical events. Since magnetic recording requires the use of electronic amplifiers which were not available until 1906, the phonograph, developed a quarter of a century before, had quite a head start on magnetic recording. Then too, it was only recently that adequate recording media became available. Wire recording using steel wire had disadvantages which were never entirely overcome. As soon as methods were discovered to produce a flexible, strong tape having a coating of uniform magnetic particle size the tape recorder crowded the wire recorder out of the competitive market.

Another deterrent to the development of magnetic recording is the fact that suitable tape handling mechanism is inherently more expensive than a turntable of comparable quality. Also by the time tape recorders were perfected and offered at reasonable price, most music enthusiasts already had substantial collections of good quality phonograph records. The added expense of purchasing a tape recorder is difficult to justify when such a large variety of excellent phonograph recordings is available. However as will be pointed out later the long run saving by taping should be enough to at least give consideration to the purchase of a tape recorder.

Advantages and Disadvantages

There are several big advantages of magnetic recording. Its use makes it possible to keep the noise level of taped program material very low. There is some noise associated with tape recording but this is negligible as compared to a disc recording with a dozen plays to its credit. Astonishingly enough, a tape actually becomes quieter with use due to the polishing action performed by its sliding over the recording head!

Another advantage is the fact that tape recordings may easily be erased and new material recorded when the old material is no longer desired. Just imagine—those Elvie Presley recordings so cherished by the teenager could someday resound to the thunder of Beethoven!

So simple is the recording technique that any untrained individual can obtain good results. No stylus

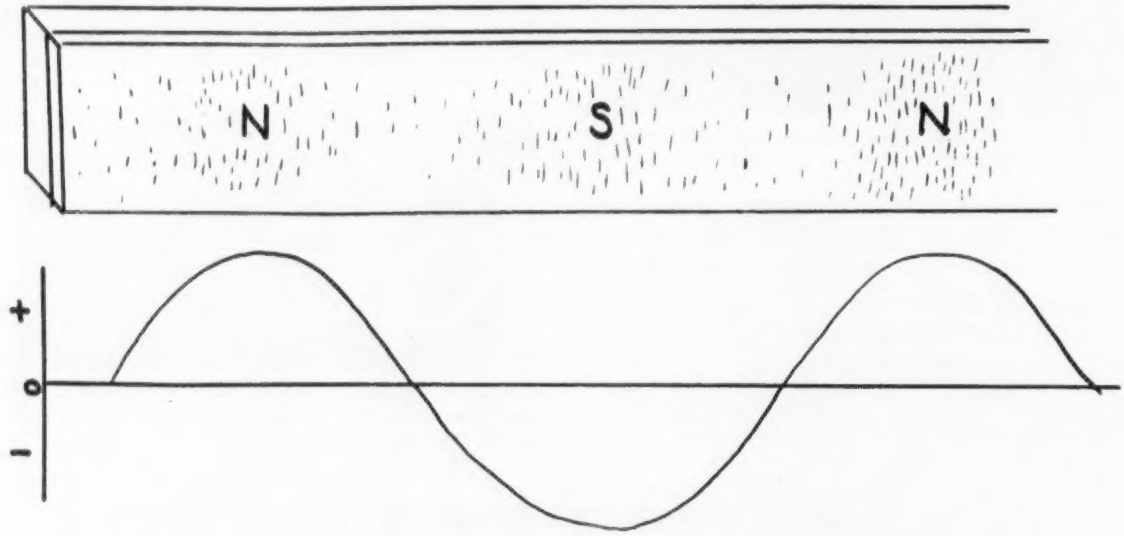

Fig. 1: Information as transferred to a tape.

adjustment, depth control, or chip removal are required.

The lack of deterioration associated with tape is another important consideration. No stylus can be blunted and grooves can not become sloppy. Since slight if any energy is removed at each playing the taped playback remains bright right up until the mechanical destruction of the tape. Contrast this to the microgroove L.P. which noticeably loses some of its crispness after the first play. Present tapes have practically "infinite" life on properly operating machines. Dust cannot cause permanent damage to tape for there is no groove in which it may lodge.

Longer uninterrupted playing time should be a very important factor in this age of "gracious living." That background music is an important psychological asset is proven when sound failure in television dramas takes place. The actors immediately lose some of their persuasiveness. Commercial installations of background music emphasize the recognition by industry of this point. Inexpensive tape recorders presently available will give hi-fi, uninterrupted music reproduction for a period of 45 minutes with only a 7 inch roll of tape!

Finally, far less operating skill is required to obtain true high-fidelity in the home. Shudder no more at the thought of dropping that high quality tone arm in the middle of one of your prize collectors discs. Don't be angry with your wife because she bumped your turntable out of level—the tape recorder will give hi-fi performance riding in a Black Diamond cattle car!

Certain factors must be considered as disadvantages of tape recording in order that a clear evaluation may be made. Of first consideration is the fact that prerecorded music is slightly more expensive to buy on tape than on disc. This does not preclude the possibility of recording from FM broadcasts or electronic copying from a friend's disc collection.

Secondly, initial application of tape to a machine is more difficult than placing a record on a turntable. However, threading techniques are far less critical than that of properly placing a precision tone arm on the rim of an L.P. disc.

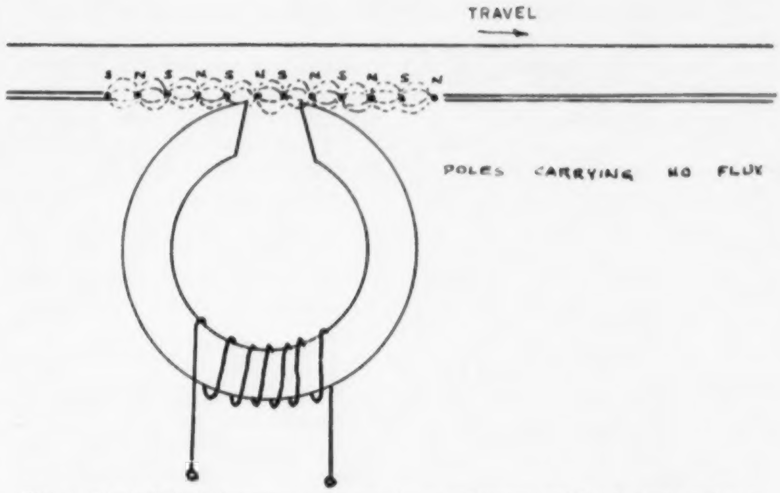

Fig. 2: Limited high frequency response due to excessive width of playback head

Theory of Magnetic Recording

One of the basic components of the magnetic recording process is the tape upon which the signal is preserved. The tape consists of a plastic or paper ribbon to which is firmly cemented a layer of iron oxide particles. These particles (1 micron in diameter) are capable of being magnetized and retaining this magnetism as tiny permanent magnets.

Information is put on the tape by magnetizing the magnetic coating. This is done by passing the tape close to an electro magnet whose coil is energized by a current proportional to the information. This magnet is called the recording head. As the tape advances past the head at a constant velocity, the information is stored in its surface as a series of nodes and peaks of magnetic flux. A representation of this along with the information (sine wave) it represents is shown in Fig. 1. Note the fringing which occurs between oppositely polarized peaks.

In order to play back this stored information, the tape need be passed over a similarly built (could be the same head) pick-up head. The flux fringe between these peaks is picked up by the iron pole pieces and passes through the coil wound thereon. A voltage may be induced in the coil due to the changing flux intercepted by it. The relation is given by $e = N\frac{d\Phi}{dt}$ where e is volts generated, N is the number of turns of wire and $\frac{d\Phi}{dt}$ is the rate of

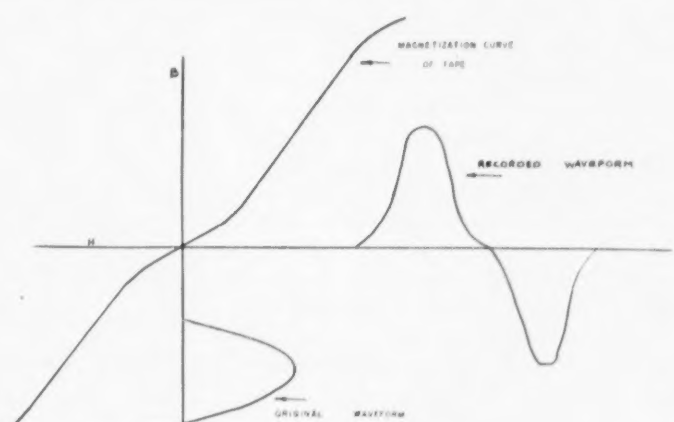

Fig. 3: Distortion due to non-linear magnetization characteristic.

change of flux through the coil. This voltage should be identical in form to the information which was initially recorded.

In order to erase the information it is necessary only to demagnetize the tiny groups of magnets or to randomly magnetize them so that there is no net external (fringe flux) flux. This may be done by applying a supersonic (50 kc) signal to the tape. This is usually applied by an erase head located immediately preceding the record head. The erase head has a wider air gap in order that the tape moves in a decreasing field as it moves away from the erase head. Thus complete demagnetization occurs through use of decreasing hysteresis loops. Other methods are used but this is the most common.

Recording Problems

Down through its development certain problems have arisen with tape recording which have taxed the ingenuity of the engineer. One of these problems is frequency response. That old headache of adequate frequency response loomed large as designers attempted to cover the range of human hearing. (20—20,000 cps.)

At the high frequency end the peaks of magnetization get very close together on tape. When they become closer together than the tips of the pole pieces on the playback head, the flux is no longer shunted through the coil by these pole pieces (See Fig. 2.). No flux changes through the coil means no voltage induced and thus the high frequency response is lost.

At the low frequency end of the spectrum we run into two very great difficulties. The voltage output has decreased at a linear rate with frequency due to the linear decrease of $\frac{d\Phi}{dt}$. This 6 db per octave decrease must be equalized (counteracted) by some type of circuitry. Equalization of this order (60db) at the low end would tend for a very poor signal to noise ratio. For instance the output of a head at 20 cps with a high level recording is only 0.2 milivolts. Keeping stray pickup and thermal noise well below this value is no small job.

The other deficiency at low frequencies again involves fringe flux. The peaks become so far apart that a portion of the flux travels completely around the pole pieces without passing through the coil.

Flutter, another recording problem, is a phenomena which is caused by jerky motion of the tape as it passes the head. Wow is a low frequency flutter arising from the same causes. A flutter causing amplitude or frequency modulation

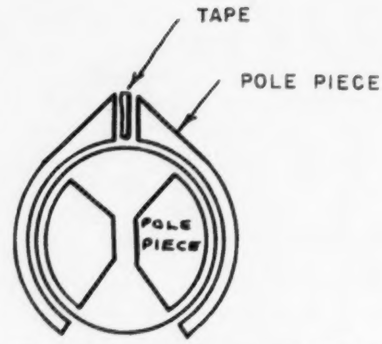

Fig. 5: Section showing perpendicular recording technique.

greater than ½% is noticeable and unpleasing to the human ear.

Recording difficulty can also arise from non-linearity of the recording media (iron oxide particles). This would lead to serious distortion as shown by Fig. 3 were measures not taken to prevent it.

Most of these problems have been ingeniously solved. Frequency response is improved by control of tape speed. Standard speeds of 3.75, 7.5, 15, and 30 inches per second have been adopted. The 7.5 inch/second speed seems to be the best compromise between high and low frequency response. Higher speeds spread peaks wider apart. This solves the problem of head gap being too wide but aggravates the fringe flux problem at low frequencies.

Proper gap width, made as small as is practical, can also improve frequency response. Not only do production problems of how to get uniform gaps of ½ mil arise but higher power is required in order to cause enough fringing at the gap to magnetize the tape.

Special ingenious heads have been devised which eliminate the problem of output being frequency dependent. The most successful is an electron beam pickup designed by J. W. Gratian. This head responds to flux intensity rather than rate of change of flux. Thus its response is uniform to as low as 1 cps. (See Fig. 4)

Longitudinal recording has been the only method mentioned here. However perpendicular recording utilizing the electron beam pickup head is capable of response to DC. The high frequency response is more limited however due to the

(Continued on Page 64)

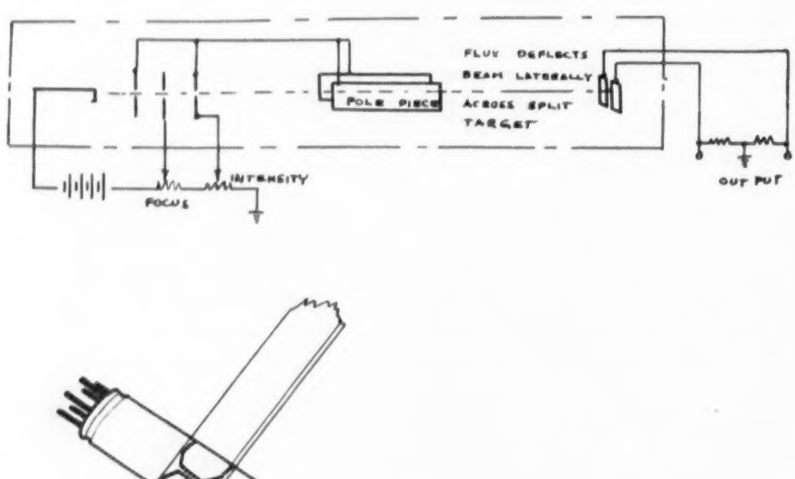

Fig. 4: Electron beam playback head.

Work with the GAS industry...
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H. BROWN BALDWIN
B. S. Mech. Eng., U. of Vermont, 1949.
Began as Cadet Engineer, Boston Gas Co., 1950. Became Staff Engineer in Distribution Development Section, 1952; Staff Engineer in charge of Development, 1955; Distribution planning Engineer, 1956. Worked closely with company's natural gas conversion programs. Now advisor to Distribution Department charged with developing processes, machines, specifications. Assists management in preparing cost estimates, job analyses, other projects.

W. C. DAHLMAN
B. S. Gas Eng., Texas A. & I., 1938.
Began as Engineer trainee with Lone Star Gas Company after graduation from Texas A. & I. with first four-year Gas Engineering degree offered by institution. Joined Houston Natural Gas Company in 1942. Became District Engineer in Texas City and then District Manager in Beeville and El Campo. Dahlman is currently Chief Engineer with full engineering responsibility throughout the twenty counties in the company's Texas Gulf Coast System.

The Gas industry—the sixth largest in the nation—has a total investment of over $15 billion. Last year the industry set a new all-time record in number of customers, volume of Gas sold, and dollar revenue. In fact, Gas contributed 25% of the total energy needs of the nation as compared with 11.3% in 1940. The Gas industry is a major force in the growth development and economic health of this country.

There are many opportunities for you in the Gas industry. The industry needs engineers, and does not over-hire. You won't be regimented. There's always room for advancement. With utility companies and with manufacturers of Gas equipment, there's a future for you as an engineer. Call your nearest Gas Utility. They'll be glad to talk with you about your opportunity in the Gas industry. *American Gas Association.*

Nickel Progress Report

A crack at the earth's surface shows bulk mining is proceeding far underground.

Panel caving is one of two bulk mining methods which account for 70 per cent of the company's total nickel output.

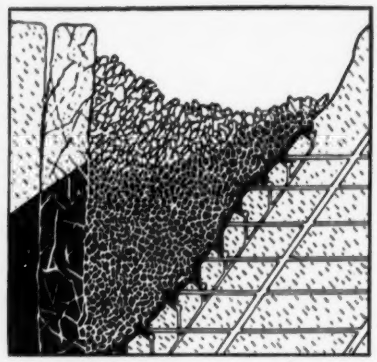

Diagram of panel caving in Creighton mine. The heavy panel of ore and rock sinks, breaking up as it moves down.

Which Mining Method is BEST?

There is no one best method of getting ore out of the ground. Type of ore; type of rock; even the location of the mine must be weighed. Inco uses five underground mining methods at Sudbury:

Square Set *Cut and Fill*
Shrinkage *Blasthole*
Panel Caving

Once only "waste rock"... now a new source of Nickel

How Inco's mine engineers utilize a panel-caving method in order to recover nickel from huge ore deposits that formerly were not practicable to mine

Panel caving is one of the newest mining methods put into use by The International Nickel Company.

The tonnage of ore handled by this method is immense. Sometimes a single block measures 200 by 800 feet. It may weigh as much as 1⅓ million tons.

As these heavy masses move downward they break into pieces small enough to drop through chutes and into machine crushers deep inside the mine. From crushers the ore goes a quarter mile by conveyor to hoists that lift it to the mine head.

From there, the ore is milled as fine as sand. The concentrate is then pumped to the Inco reduction plant 7½ miles away.

Panel mining; new concentrating machinery; new, continuously improved operating practices; pipeline transport. Add them together and you can see how they make possible production of nickel from ore deposits once only "waste rock."

Inco has prepared a full-color sound film—*Mining for Nickel*—that shows the operations of modern nickel mines. 16mm prints are loaned for showings before technical societies, engineering classes of universities and industrial organizations. For details, write Dept. 130f,

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NUCLEAR POWER

(Continued from Page 16)

fuel. Based on the assumption that plutonium sale offsets all fuel costs, both plants designed by this group are economically competitive with conventional coal-burning plants. Using this reactor in a single-purpose plant, however, results in power costs of 37.7 mills per kilowatt-hour for a 15-year amortization period, and 14.5 mills per kilowatt-hour for a 20-year amortization period, neither of which favorably compare with conventionally-produced power at 6 mills per kilowatt-hour. A single-purpose plant will be competitive if operated as a dual-purpose plant during the initial 5-year amortization period when fixed charges are high, and then operated for power only.

The Bechtel Corporation–Pacific Gas & Electric Company studied a heavy-water-moderated, light-water-cooled thermal reactor using natural uranium fuel, and a liquid-sodium-cooled fast breeder reactor using enriched uranium fuel. Both are operated as dual-purpose reactors, and both are competitive with coal-burning plants assuming plutonium sales offset all fuel costs, and assuming an amortization period of 20 years, both assumptions not completely justified.

Although not economically feasible at the present time, single-purpose reactors will almost certainly be operating competitively with coal-burning plants before 1965. Optimism about the future technological development in nuclear engineering has been shown by both the Duquesne Light Company, who will operate a 60,000-kilowatt nuclear power plant now under construction at Shippingport, Pennsylvania, and the Consolidated Edison Company, who has just announced plans to build a 200,000-kilowatt nuclear plant for the production of power in the New York City area. That these plants will be operating at a profit in the not-too-distant future is almost a certainty. In the words of the Atomic Energy Commission:

> Obtaining full participation of the Nation's electric energy producers and equipment manufacturers in the development and production of nuclear power is in our judgment the best way of securing the maximum return on the public investment in this phase of the atomic energy program. The accumulated stockpile of fissionable materials, now in the hands of the Government, are a national resource. Putting this resource to work . . . to strengthen the economy . . . will most quickly and surely achieve and spread its benefits.*

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RHAPSODIES IN WRAPPING PAPER

(Continued from Page 28)

in Florida is graced with a few old automatic pianos, Knott's Berry Farm in Corona, California, has an interesting collection, and so does the Cliff House in San Francisco. There are others, but these are some of the best known collections open to the public.

And Then Violins

Another famous contrivance is the famous Mills Violano Virtuoso—the machine that plays a violin in accompaniment to the piano. This is not to say that the Mills is the only such outfit. Hupfeld of Germany built a machine with three violins, called the "Phono-Lizst-Violina." There were banjo playing machines, too, but the Mills Novelty Company of Chicago made the biggest commercial success in this field. The Violano first appeared in 1907, as a violin player, and then in 1912 came on the market as a combination 44 note piano and violin player and remained on the market until about 1925. The Mills company claimed in its advertising that the Violano was designated "one of the eight greatest inventions of the decade" by the United States Government!

In this device, insertion of a coin makes contact to start a large AC-DC rotary converter in the base of the cabinet, making 110 volt DC from AC. Of course many of the earlier machines were battery operated and also had to operate from odd voltages and frequencies before 60 cycle AC became common. The piano soundboard is quite unusual, in that it has 44 notes and the long strings are placed in the center of the harp—an arrangement which would be highly desirable for any piano (but practical only when under electrical operation) because of uniform stressing of the cast metal plate. The notes are struck by solenoids, acting upon orders from impulses received by wire brushes making contact upon a steel roller through perforations in the music roll in a manner surprisingly similar to the familiar International Business Machines card equipments! The paper roll is driven by a DC motor, gov-

(Continued on Page 64)

BRAIN TEASERS

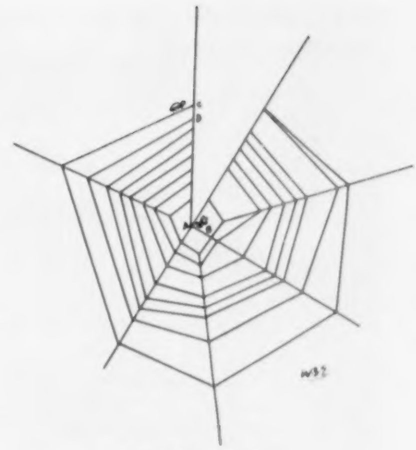
1. Not long ago, the *Engineer* editors were amusing themselves, watching the spiders crawl around between the stacks of advertising plates. One particular spider, named Marty, was building himself an exceptionally fine web.

As the editors watched, Marty's lunchtime drew near. Most conveniently, a fly flew into the web and landed at A. Marty, at this time, was at C.

Marty, who has a rather morbid sense of humor, likes to watch his prey for a while before his dinner. Therefore, instead of rushing over to devour the fly, he merely advanced to D, where he remained for a moment. The fly, at this, took new hope and advanced to B. (The fly was able to unstick one foot, and so walk on the web, but could not remove both feet in order to fly away.) This continued for some time, with each moving in turn along a strand from one intersection to the next. Finally, the fly found that after he had moved, he was diagonally opposite one of the rectangles from the spider. They went around and around the rectangle for several minutes, and the fly began to think that he was safe from the spider. Marty, however, finally managed to catch and devour the fly.

How did Marty catch the fly? Remember, Marty moves first from the position shown in the diagram.

2. Yesterday, a number of us were playing a variation of pool called "rotation." The object of the game is to sink the fifteen balls in a certain order. Any ball may be sunk first, but subsequent balls must be sunk so as to form an unbroken sequence with the previous ones. (For example, if the five, six, and seven have been sunk, then either the four or the eight ball may be sunk on the next shot.



"Marty's web."

How many different orders are there for sinking the balls?

3. A "quickie" to ruin your sleep tonight: Somewhere in an obscure math course, we learned that the letter "i" is often used to represent the square root of minus one. If this is the case, then what does i^i (yes, i to the i power) equal? Believe it or not, i^i is a real number!

RHAPSODIES IN WRAPPING PAPER

(Continued from Page 60)

ernor controlled in such a manner that its speed varies continuously through the five tunes on the 5" diameter roll, to compensate for the paper building up on the take-up spool.

The greatest difficulty in getting a violin to operate automatically would naturally be that of keeping it in tune, but the Mills has a very simple way of doing this. Instead of having tuning pins, as in a regular violin, Fig. 6 shows at A the adjustable weights hung on each of four tuning arms, fulcumed at the end near the violin scroll. The string is kept taut by the action of the weight, and tuning is provided by moving the weight on the arm, much in the manner of a scale balance. Since the load per unit area of the string cross section is therefore constant, once the weight is adjusted properly, the string will not change in tune providing the humidity is fairly constant.

F is the bow motor, a DC motor wired in such a way that it will operate at four different speeds, to accomplish what the violinist does by bowing faster or slower. A set of four helical gears in front of the motor transmits this rotary motion to four small celluloid discs, immediately under C. When a particular note to be played is indicated by the paper roll, the bowing disc is made to touch the string by a magnet operating on its support lever. At the same time it is necessary for the strings to be fingered, and this is done by a series of levers and magnets seen immediately back of the violin neck.

C is a rosin cake holder. After playing five tunes, the machine automatically re-rolls the paper roll, and while this is being done the rosin is automatically pressed against the bowing discs, to prepare them for playing the five selections over again!

The single Mills machine illustrated was sold for around $2500, and a larger model with two violins mounted one above the other sold for $3200. Imagine what this would mean in today's money! But they were often quick to pay for themselves. A man who once owned a ice cream parlor bought one of the large machines around 1918 and it paid for itself—all thirty-two-hundred dollars—in nickels taken in the first year of its operation! Of course in later years, after the advent of the automatic phonograph, it hardly took in ten cents a week.

But while there is a flurry of interest in players today, most of these more interesting types of machines will only be kept by a few collectors.

MACHINES THAT ARE HUMAN

(Continued from Page 49)

A Human Machine?

To the casual observer, this behavior is all too human. It hints at a future universe where man has become the robot, for if a simple animal with unpredictable behavior can be built, why not a more complex creature with disasterously unpredictable consequences? This is reminiscent of the science fiction story wherein all the electronic computers of the universe were connected together and a question of ultimate importance was asked, "Is there a God?" The machine's simple answer, "Now there is!"

Fortunately this is a hypothetical situation, because, for this story to come true we would have to be able to describe, in full detail, the complex process of creative thinking. For a creature of only two cells, seven modes of existence are possible. And, to quote Dr. Walter, "With six units there would be enough modes to provide a new experience every tenth of a second throughout a long lifetime." Since the human brain possesses about ten thousand million elements, and since the number of modes of existence is given by the formula,

$$M=2^{(n^2-n)}$$

where n is the number of elements, we are, therefore, capable of approximately $2^{10^{20}}$ ways of behavior. The difficulties in describing this fantastically great number of modes of behavior are obvious. A whole world of people could barely begin this task even if they worked continuously through many lifetimes.

It has been stated that man can duplicate only those things he can accurately describe. Thus, the improbability of ever completely describing the thinking process rules out the science fiction "monster". Even Hollywood found this task to be too great, for, although Robby was a very brilliant robot, there was, after all, a man inside him!

By now the reader may rightly ask, "So what? Are these little electro-mechanical machines of any use?" To answer this, I quote Dr. Walter: "As toys they refresh the spirit of the laboratory children we all are, leading us to familiarity with more and more elaborate mechanisms. As tools they are trustworthy instruments of exploration and frequent unexpected enlightenment. As totems they foster reverence for the life they have so laboriously been made to mime in such very humble fashion—and still would foster it even should they, creatures of "sorcery" peering into the dim "electrobiological" future in search of a *deus ex machina*, look up at us and declare that God is a physiologist."

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WHY MAGNETIC TAPE RECORDINGS?

(Continued from Page 56)

necessity of using thick pole pieces. This method is shown in Fig. 5

Flutter and wow are caused by mechanical troubles in the tape handling mechanism. Flat spots on capstans and idlers are usually at fault. Large, heavy flywheels on capstan shafts also tends to reduce flutter.

The problem of non-linearity is solved by the use of a method of magnetic bias. This magnetic bias makes it possible to operate on the linear portion of the magnetization curve. The bias tends to put alternate magnetic poles on the tape at a supersonic rate. One would think then that this super-

sonic information would be apparent on playback. However, the response, it will be remembered, drops off rapidly at 20 kc. The overall effect is for the head to respond to the net flux intensity on the tape.

From the foregoing explanation it is quite evident that tape recording has presented many engineering problems. It should be borne in mind that these problems have been mastered to the extent that exceptionally good service and long life are available today.

Purchasing Considerations

Should it be desired to purchase a tape recorder the following information will be helpful in the choice of an instrument for home use.

1. Frequency Response. At least 50-10,000 cps. ± 2 db on the 7.5 inch/second speed.

2. Tape Speeds. For economy both 3.75 and 7.5 inch per second speeds should be included.

3. Dual Track. The practice of recording different material on opposite edges of the tape is nearly standardized. This doubles the amount of material which a tape may carry.

4. Flutter. At most 0.5% flutter or wow.

5. Power Amplifier. It is not wholly necessary to have a built-in amplifier if the recorder is to be used in conjunction with a separate amplifying system. It is sometimes handy to have a built-in power amplifier if the recorder is to be used as a portable instrument.

The user will be most satisfied if the above specifications are used as a guide in the purchase of a tape recorder. There are instruments on the market which retail for approximately $100 and are quite satisfactory.

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President's Message . . .

SECURITY VS. NEW FRONTIERS

The criers of doom have always been with us and always will be. They are proven wrong over the long period. Like any small vociferous group, they get publicity all out of proportion to their stature or the soundness of their theories. As a result they are able to gather a few followers, and indirectly to influence the thinking of many. For ten years now, since World War II, they have forecast a depression for each year with their familiar, but shop-worn "Remember 1929". A bit of this is bound to rub off and is at least partially responsible for the emphasis on "security" by too many of our young men and women today.

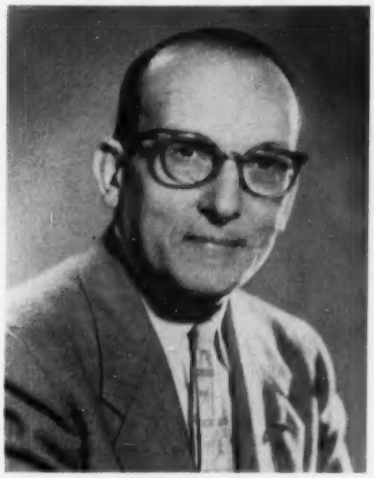
Then there is the group who cry that the dynamism of America stopped with the opening of the last frontier—meaning, of course, the last geographical frontier. They fail to recognize or feel the pulse of the even greater dynamism being produced by science in which the new frontiers are apparently limitless. For example, it is estimated that nuclear science alone will soon be required to supply more power than could ever be produced from all the current or potential water sources on earth.

The world's population is growing at a dynamic rate, currently estimated at a *net gain* of one person per second. The current production of food and other vital necessities is falling rapidly behind this demand. The population of the United States is estimated at 200 millions by 1975 and it now appears we may hit this figure before that date. This increase in our population will require at least a 50 per cent increase in food production by that date over 1955! The new frontiers which must be opened in every field of endeavor to supply the world demand with the simplest necessities are numerically sufficient to stagger the imagination.

The new frontiers are here; all we need is a rebirth of the pioneer spirit to conquer them. The pioneer spirit isn't interested in pension plans, social security and other trappings for old age. The pioneer will provide for his own security when and if the time comes that he needs it. He doesn't sell his ambition to government civil service or the giant corporation *just* because there is potentially a greater security with them. The price of such security—as contrasted with providing for your own future security—is high in potential loss of initiative and individuality, in degradation of ambition and in diminution of self-respect. The rewards for a pioneer are measured only by his own efforts and ability.

When the next personnel representative visits the campus, don't ask him about pension plans, but find out where his company is going, what their plans are for the next ten and twenty years in seeking and conquering new frontiers. How can you fit in this picture, unbounded by security-minded superiors, to advance and become part of this team of pioneers. There are plenty of such companies who operate under the principle of one of Wall Street's most successful investors: "Sell America Long".

ALUMNI ENGINEERS



S. R. Hirsch.

Sylvan R. Hirsch, ME '25, has been appointed Assistant to the Vice President-Engineering at the Worthington Company's Harrison Division. A native of Savanah, Ga., Mr. Hirsch joined the Worthington Cincinnati Office following his graduation from the University. In 1934 he was transferred to the company's Harrison Division where he served as Assistant Chief Engineer in the Refrigerator Division. In 1955 he was appointed Manager of Engineering at the Holyoke Branch at which post he served until his present promotion.

Edgar H. Dix, Jr., MME '16, was presented with the Albert Sauveur Achievement Award at the annual meeting of the American Society of Metals in recognition of his outstanding work in aluminum alloys research. Mr. Dix is assistant director of research of the Aluminum Company of America, located at the company's laboratory in New Kensington, Pa. He started his work in aluminum alloys back in 1919 with Aluminum Casting Company. In 1921 he became chief of the metals branch, Engineering Division, Air Service, McKook Field. He has been with Alcoa since 1923. Mr. Dix was chairman of the Pittsburgh Chapter of the ASM in 1931-32. In addition he is affiliated with numerous other technical societies.

H. Alfred Stalfort, CE '34, has been elected president of the Engineering Club of Baltimore for 1957.

Morgan Tibbett, ME '36, is now in Tehran, Iran, as a member of a two man economic team charged with the task of devising a comprehensive plan in oil development for the Iranian government. It is part of an Iranian seven-year program of organization. Mr. Tibbett is an affiliate of the Ford Foundation in this operation, and expects to be there two years.

Col. Stanley T. B. Johnson, MCE '38, has been named district engineer of the U.S. Army Engineer District in Baltimore, Md.

He will direct military construction in Maryland and parts of Pennsylvania, including projects at Aberdeen Proving Ground, Fort George G. Meade, Army Chemical Center and Fort Holabird.

Further responsibilities will be river and harbor activities, maintenance of Baltimore harbor and channels, and flood control work in the Susquehanna watershed.

Colonel Johnson graduated from West Point in 1935 and received a master's degree in civil engineering at Cornell in 1938. Most recently he was corps engineer with the First Army Corps in Korea.

George E. Munschauer, ME '27, has become chairman of the board and chief executive officer of the Niagara Machine & Tool Works. Mr. G. E. Munschauer has been with Niagara since 1928, having served as treasurer and a director since 1941 and vice president and treasurer since 1945. He has been active in product engineering since joining the company.

Frederick E. Munschauer, Jr., ME '41, has been appointed the new president and general manager of Niagara Machine & Tool Works. Mr. Munschauer, Jr. has been vice president in charge of manufacturing and industrial relations since 1953 and a director since 1947. He was appointed works manager in 1946. A grandson of the founder, Mr. Munschauer, Jr. entered the employ of Niagara two years prior to his graduation from the University.

Rex A. Daddisman, CE '22, is in the real estate and construction business. He is now engaged in the financing, construction, and leasing of industrial plants in California. His address is 575 Oregon St., San Francisco 22, California.

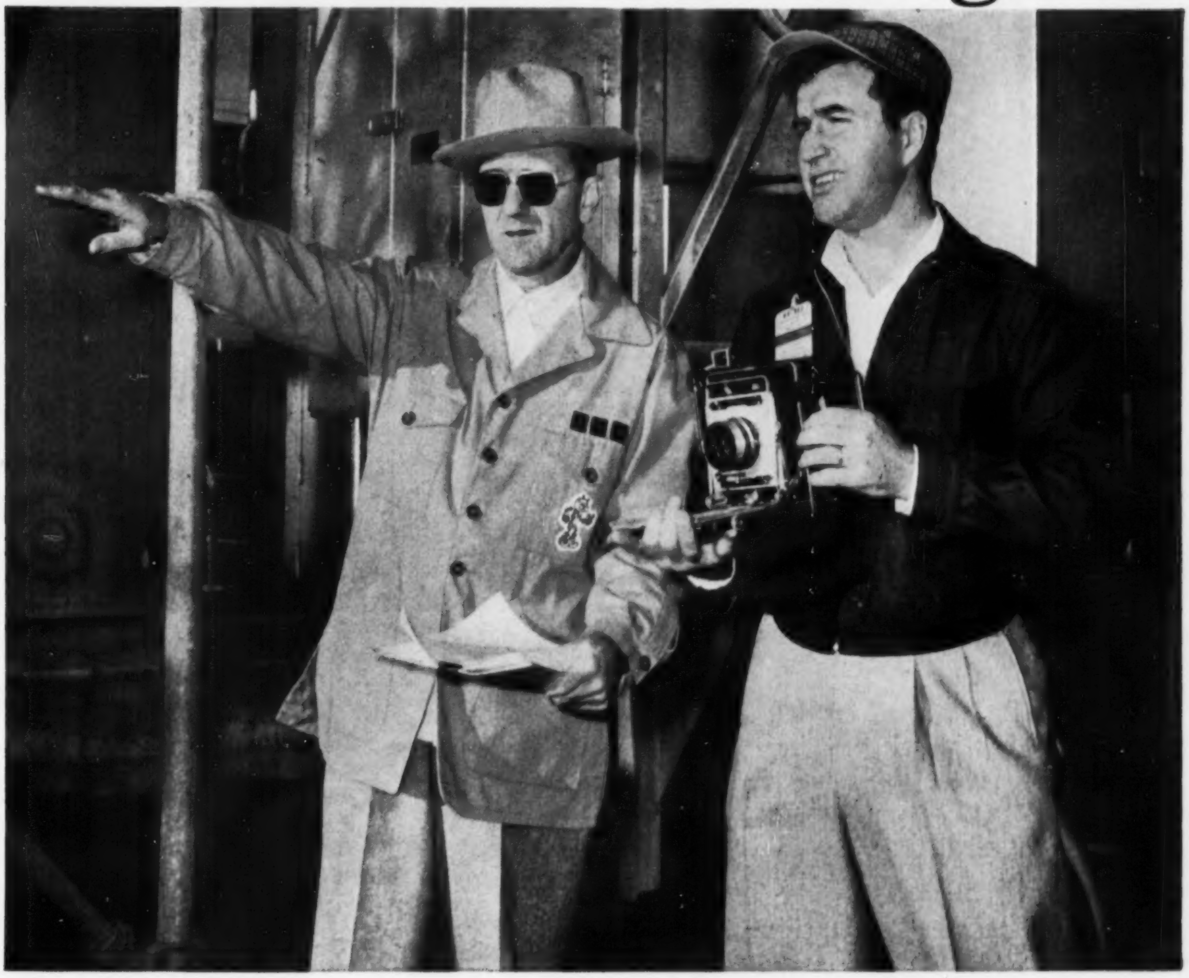
Orin R. Severn, EE '24, is division patent counsel for the Electronics Division of Curtis Wright at Carlstadt, N.J. He is a member of the Cornell Club of Essex County and the American Patent Bar Association.

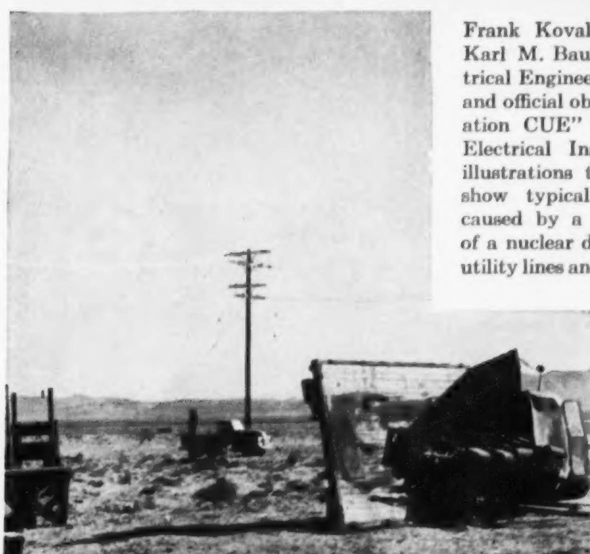
Thomas M. Tooke, ME '42, has been appointed supervising engineer in the Engineering Project Group at Monsanto Chemical Company's Springfield, Mass. division. Mr. Tooke is an active member of American Society of Mechanical Engineers. His present address is 32 Charlton St., Springfield, Mass.

Edward C. Sargent, ChemE '44, has been appointed president of the Zirconium Corp. of America. He joined the firm last February as vice-president and general manager. Previously he had served as project manager for the Vitro Engineering Division, Vitro Corporation of America, and as Cleveland area manager for the Atomic Energy Commission. Mr. Sargent is married, has four sons, and lives at Trails End Drive, Aurora, Ohio.

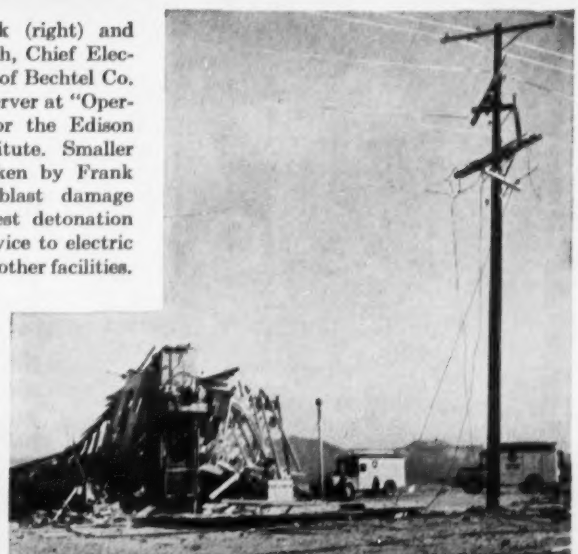
Edward C. Sargent.

...an editor on the go





Frank Kovalcik (right) and Karl M. Bausch, Chief Electrical Engineer of Bechtel Co. and official observer at "Operation CUE" for the Edison Electrical Institute. Smaller illustrations taken by Frank show typical blast damage caused by a test detonation of a nuclear device to electric utility lines and other facilities.




BUSINESS CONFERENCE
The never-ending search for oil takes men to strange places—even to ocean floors.
Here Mobil scientists, the first company team of research geologists trained as skin divers, probe the bottom of the Gulf of Mexico.
From their findings have come clues which may lead to the location of new oil reserves to strengthen the Free World—to guarantee you a continuous and abundant flow of the thousands of products made from petroleum to enrich your life.
Geology is but one of many professions represented on the world-wide roster of Mobil personnel. We also employ nuclear physicists, mathematicians, chemists and engineers of every type, marketing analysts, marketers . . . people prepared to handle more than 100 different positions.
If you qualify, the Mobil companies offer you an opportunity to build a career through training that will utilize your talents to the fullest . . . constantly challenge your ingenuity . . . reward you with a lifetime of richly satisfying work.
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and other foreign producing companies

TECHNIBRIEFS

POCKET-SIZE TELEVISION CAMERA FOR MILITARY CLOSED-CIRCUIT APPLICATIONS

A pocket-size live television camera has been developed for military airborne, mobile, and field-closed-circuit TV applications.

The ultra-miniature TV camera, developed by engineers of the RCA Surface Communications Department, was made possible by a new design approach which combines transistors, specially developed transistor circuitry, and a new RCA half-inch vidicon camera tube.

The pocket-size TV camera (JTV-1) weighs less than a pound and measures only 1⅞ by 2⅜ by 4½ inches; yet surpasses standard vidicon-type industrial TV cameras in sensitivity. Used with an F-1.9 lens, it requires only 10 foot candles of scene illumination for clear, contrasting pictures.

Lower frame of power shovel weighing 300 tons. Hollow center will contain an elevator.

The RCA pocket-size television camera represents a significant advance in the military television art. Its ultra-miniature size, simplicity, and flexibility will open new fields of application for closed-circuit television, permitting direct observation and reconnaissance in places and locations heretofore inaccessible to existing TV camera equipment. In airborne and mobile use, the ultra-miniature camera promises quality television with important savings in vital space and power. The camera literally places in the hand of the military services an important new medium for tele-observation.

The new military TV camera incorporates numerous design and performance features for maximum flexibility and operating convenience.

1—The camera can be operated in the palm of the hand, used with an attachable pistol-grip handle, bolted to wall or floor, or mounted on a tripod.

2—It is the first TV camera of its type to incorporate a photoelectric iris control, which automatically activates specific camera circuits to compensate for changing light levels. The photoelectric iris control enables the camera to accommodate changes in the order of 100 to 1 in scene lighting.

3—Designed for maximum power economy, the camera system operates from a 115-volt, 60 cycle AC source and draws less than 350 watts. Camera dissipation is only three watts.

4—Made rugged for military airborne, mobile, and field requirements, the pocket-size camera has a high level of resistance to shock and vibration. For unusual shock and vibration conditions, the camera design permits encasing of the complete internal construction in standard potting compounds.

5—Featuring virtually uprecedented design and operating simplicity, the camera can be operated by non-technical personnel. Once optical and electrical focus are fixed for a specific application it rarely requires control adjustments.

VOLCANO'S POWER HARNESSED

An Italian volcano has been harnessed to generate power and supply sulphur. Steam from a volcano at Larderello is passed through dry boxes to remove carbon dioxide and hydrogen sulfide. The sulfide is then broken down to sulphur. The station generates 260,000 kw. In addition about 30 tons of sulphur are recovered daily.

METAL TO HELP CRACK JET 'HEAT BARRIER'

A new high-strength, high-temperature metal which is designed to help push back the "heat barrier" now being encountered by jet engines in the nation's new supersonic aircraft has been developed. Announcement of the metal, for use inside the red-hot interiors of jet engines, was made by Westinghouse Materials Engineering Department. It is described as "significant advancement in the field of gas turbine disc materials."

"As jet planes travel faster and faster into the realm of supersonic flight, they encounter what is commonly called the 'heat barrier'—excessive heating of the plane due to its own impact with the onrushing air. It is the same phenomenon which causes a meteorite to burn to ashes as it falls at high speed through the earth's atmosphere. In aircraft, this heating creates many serious problems, not only in the general structure of the plane, but also in the jet engine which powers it."

Impact heating is now a major consideration in the design of the inlet and compressor of modern jet engines. By using titanium for those parts that were formerly made of aluminum, magnesium and low-alloy stainless steels, engineers can protect these sections of the engine from the effects of impact heating without sacrificing the turbojet's light-weight advantage.

However, back in the turbine section of the engine exists what might be called a second "heat barrier" which is proving to be a much more difficult problem for the turbojet designer. A jet engine gets its energy for propulsion by increasing the temperature of the air passing through it. As a general rule, the greater the increase in air temperature, the more thrust a given engine will produce and the faster the airplane will fly. If the speeds of new fighters, bombers and missiles are to continue up the supersonic scale, their engines must be able to run at higher and higher temperatures; and they must do this without having any of their components suffer significant losses in mechanical strength. The new Westinghouse metal is intended as a structural material for use in the turbine section of the jet engine, where the hottest moving parts are found. It offers special promise as a material for constructing turbine discs.

A jet engine turbine disc is a metal wheel that is bolted to the aft end of the rotating shaft of the engine. Anchored to its outer rim are some 50 or more turbine blades. White-hot gases from the burning fuel push against the blades and spin the disc and shaft at speeds up to 20,000 revolutions per minute. The disc, whirling at red-hot temperatures, undergoes stresses as great as 50,000 pounds per square inch.

The new material, which is referred to simply as W545, is an alloy of six essential elements: iron, nickel, chromium, and in smaller proportions, molybdenum, titanium and boron.

Increasing the operating strength of temperature of a high-temperature alloy can be done by adding greater quantities of these ingredients which cause hardening in the alloy. However, this procedure usually results in a loss of ductility, causing the alloy to become brittle and more susceptible to fracture. This low ductility starts to grow during the hardening process when imperfections and dislocations of the atoms occur along the individual grain boundaries of the alloy. It appeared likely that one solution to the problem might be to fill up these spider-web lines of brittleness to make the precipitation reaction more generalized within the grains rather than concentrated at the boundaries. This called for an element whose atom was of such a size that it would not merely move in and be a substitute in the alloy lattice for one of the iron, cobalt, nickel or chromium atoms, which are all about identical in size. It would also have to be a larger size atom than carbon, nitrogen, or oxygen which can actually slip inside the crystal lattice of the alloy. The element boron filled the bill. Approximately ¾ the size of the iron atom, it is too small to be a substitutional type atom and too large to be the interstitial type.

Laboratory quantities of W545 were prepared by melting in an induction-type furnace. The ingots obtained were processed into specimens, which were tested for stress-rupture strength under severe temperature conditions.

Tests show W545 to be an outstanding high-strength, high-temperature alloy. When heated to a temperature of 1200 degress Fah-

Ultra-miniature TV camera, built around transistors and a new 1/2-inch "Vidicon" pick-up tube, weighs less than a pound. Mounting shown is optional.

Electric power shovel towers sixteen stories high.

renheit and subjected to a stress of 75,000 pounds per square inch, the W545 test samples withstood these conditions for as much as 300 hours without breaking. Under equivalent conditions, standard turbine disc materials would probably have a lifetime of less than ten hours.

OIL ADDITIVE STOPS SLUDGING IN "STOP-AND-GO" DRIVING

Harmful sludging of engines, most severe under "stop-and-go" driving conditions, may be halted by a new motor oil additive.

Automotive engineers define "stop-and-go" driving as consisting of trips under 10 miles in city and suburban traffic, the minimum distance required to heat oil to proper operating temperature. Three-fourths of all trips are less than 10 miles. In this kind of short haul service, formation of sludge is relatively rapid.

The Du Pont additive is unique because it works in the presence of water—and water is a foremost reason why "stop-and-go" driving is so highly conducive to sludge formation. A pint of water is formed for every gallon of gas burned. Some of it slips past the oil rings as moisture. The comparatively cool crankcase condenses this moisture into water, which, upon joining the combustion products in the oil, forms tiny particles of sludge.

The Du Pont additive immediately surrounds each individual particle of sludge in a chemical raincoat of its own. Packaged particles cannot join forces and settle, but remain suspended in the oil. So small they are invisible, they easily pass through the oil screen and filter and are drained off when oil is changed.

MACHINE TESTS SPRING WIRE

A recently constructed machine for fatigue-testing small diameter wire is proving very useful in studies of spring materials at the National Bureau of Standards. Developed by J. A. Bennett and H. C. Burnett of the Bureau's mechanical metallurgy laboratory, the machine stresses the straight wire sample in reversed torsion, simulating the stresses in a coiled spring under fluctuating tension or compression load. Results obtained with straight wire in this way show good corre-

(Continued on Page 77)

TECHNIBRIEFS

(Continued from Page 74)

lation with the results of fatigue tests on compression springs coiled from similar wire.

Because helical springs are often used in applications where they are subjected to many cycles of fluctuating load, their fatigue properties are of major importance. To provide data in this area, the Army Ordnance Corps has for several years sponsored a study of the fatigue properties of spring materials at the Bureau. However, fatigue tests on compression springs are time consuming, and special care is required in coiling, grinding, and measuring the spring before test. The present machine was designed to determine the torsional fatigue properties of spring wire without need of coiling wire into springs. Set-up time is thus greatly reduced as the ends of the straight-wire specimens need only be bent at right angles.

The machine consists essentially of two aligned grip heads that hold the wire specimen while they oscillate individually through an angle of about 120 degrees. The amplitude of deflection in the specimen is set by means of an adjustable coupling that shifts the phase relation between the oscillating grips.

Power is provided by a 1/20-horsepower electric motor. The motor causes rotation of a horizontal shaft which is connected at one end to a second horizontal shaft by the adjustable coupling previously mentioned. The free ends of the two horizontal shafts are connected to the shafts of the grip heads by crank mechanisms in such a way as to cause oscillatory motion of the grip heads. Thus, by adjusting the coupling, the relative motion of the two heads can be controlled.

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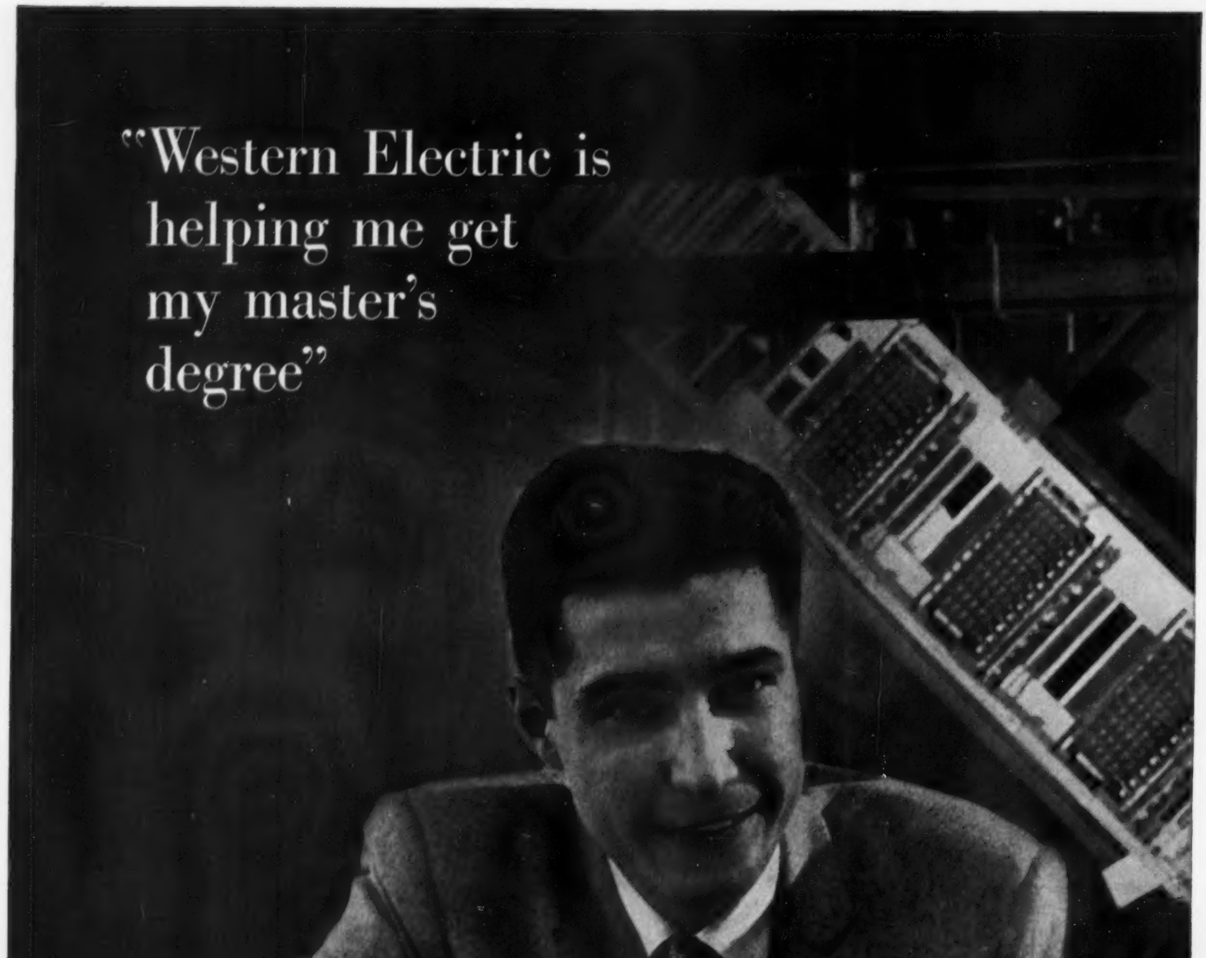


JOHN MORAN, who joined Western Electric's engineering staff at the Kearny Works recently, is now studying for his M.S.M.E. under the new Tuition Refund Plan. Western Electric expects to refund the tuition for John's graduate study at the Newark College of Engineering this year.

STRESS *and* STRAIN . . .

A professor is a man whose job it is to tell students how to solve the problems of life which he himself has tried to avoid by becoming a professor.

° ° °

A college student arrived at the Pearly Gates where St. Peter asked him who he was. When told he was an Arts student, St. Peter said, "Go to the Devil." Some time later an Ag student arrived, and upon being asked who he was, replied that he was an Ag student. He was told to go to Hades. The third student arrived at the Pearly Gates with his slide rule. When asked who he was, he replied, "I'm an engineer," whereupon St. Peter said, "Come in, son, you've been through Hell already."

° ° °

And there was the freshman in engineering that thought steel wool was the fleece of a hydraulic ram.

° ° °

Two junior EE's had just completed a stiff Mechanics exam and were discussing it in the Straight.

First EE: How far were you from the right answer on the second problem?

Second EE: Two seats.

° ° °

A patient in a lunatic ward insisted he was Adolph Hitler.

"Who gave you that name?" the doctor inquired.

"God gave it to me," said the patient.

"No, I didn't," answered a voice from a neighboring bed.

° ° °

A chaperone is a force acting on a couple to maintain it in a state of equilibrium.

° ° °

My parents taught me not to smoke;
I don't.
Nor listen to a dirty joke;
I don't.
They make it clear I must not wink
At pretty girls, nor even think
About intoxicating drink;
I don't.
To sow "wild oats" is very wrong;
I don't.
Wild youths chase women, wine and song;
I don't kiss girls, not a single one,
I don't even know how it's done,
You'd think that I wouldn't have much fun;
I don't.

° ° °

Victims of an accident in Scotland were still lying on the road. Along came a native and said to a man lying on his back: "Has the insurance man been 'roon yet?"

"No," was the reply.

"Ah, weel," said the Scot, "I'll just lie doon aside ye."

° ° °

"Won't your wife hit the ceiling when you get home tonight?"

"She probably will; she's a poor shot."

° ° °

Tourist: "What do you do all day?"
Student: "Hunt and drink."
Tourist: "What do you hunt?"
Student: "Drink."

° ° °

Hygiene Prof.: "What are the bones in your hand called?"

C.E.: "Dice."

° ° °

He rounded the bend at close to 40. A sudden skid and the car overturned. They found themselves sitting close together, unhurt, alongside the completely smashed car. He put his arm around her waist.

"It's all very nice," she said, "but wouldn't it have been easier to run out of gas?"

° ° °

PROPHECY ON ENGINEERS

"Verily, I say unto you, marry not an engineer, for an engineer is a strange being and is possessed of many evils. Yea, he speaketh eternally in parables which he calleth formulae . . . He showeth always a serious aspect and seemeth not to know how to smile, and he picketh a seat in a car by the springs therein and not by the damsels. Verily, though his damsel expecteth chocolates when he calleth, she openeth the package to disclose samples of iron ore. Yea, he holdeth her hand but to measure the friction therein. And he kisseth her only to test the viscosity of her lips. For in his eyes there shineth a faraway look that is neither love nor longing—rather a vain attempt to recall a formula . . . Even as a boy he pulleth a girl's hair but to test its elasticity. But as a man he discovereth different devices; for he counteth the vibrations of her heart strings . . . His marriage will be a simultaneous equation involving two unknowns yielding diverse results . . .

° ° °

The R.O.T.C.
May be a good thing;
We learn marching, shooting,
And skirmishing.
Statistics, ballistics,
First-aid, parade,
A wealth of things
And yet I'm afraid;
In the frenzy of war
There's more to be said,
For a two-year course
In dodging lead.

° ° °

And then there was the business statistics student who ruined a mechanical calculator when he divided a number by zero and burned out the bearings.

° ° °

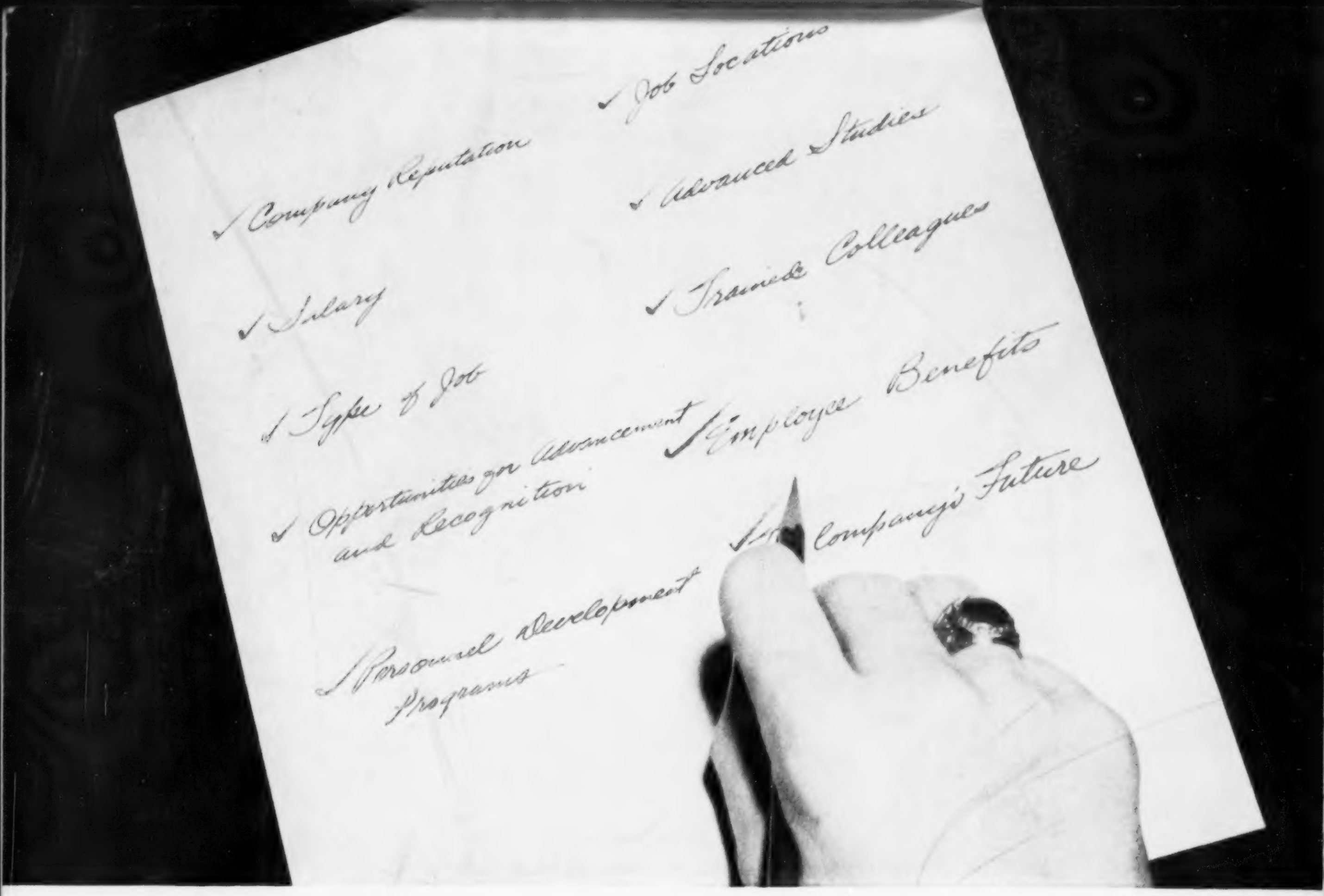
She doesn't drink
She doesn't pet
She doesn't go
To college yet.

° ° °

An electron is a very small dot of nobody knows what, that goes like H— backwards from the way that electricity really goes, and then gets all screwed up and loses its sense of direction when the magnetic field is fluxing.

° ° °

Curious fly
Vinegar jug
Slippery edge
Pickled bug.



How General Electric stacks up on your job check list

• **COMPANY REPUTATION**—As an engineer, the names of Thomas Edison and Charles Steinmetz should be known to you. These men, who so greatly influenced the industrial surge of our country since the 19th century, are symbolic of General Electric's past and present technological leadership.

• **SALARY**—General Electric's salary program is planned with a long-range view for your career; a well-considered starting salary and merit increases based on your contributions. Through regular counseling by your supervisor you know just "how you are progressing".

• **OPPORTUNITIES FOR ADVANCEMENT**—Through the Company's Personnel Registers, and individual appraisal of your qualifications and preferences, you are considered for all new or related jobs and promotions throughout the Company.

• **TYPE OF JOB**—Based on your personal preferences and abilities, you will work in various marketing, manufacturing or engineering fields. Your technical or managerial experiences may be in any of nearly 100 product departments where you contribute to the engineering, manufacturing or marketing of some of the more than 200,000 G-E products.

• **PERSONNEL DEVELOPMENT PROGRAMS**—General Electric, a pioneer in industrial training programs, hastens your professional development through classroom and on-the-job assignments as a part of the Company's marketing, manufacturing and engineering programs. Specific position placement is also available if your interests are already formulated.

• **JOB LOCATION**—There are opportunities for you as a G-E engineer in 150 cities in 45 states, plus many foreign countries.

• **ADVANCED STUDIES**—General Electric offers to technical graduates the Tuition Refund Program and Honors Program for Graduate Study wherein you may take graduate courses at nearby universities. In addition, G.E. sponsors graduate-level Company courses where top professional men teach in their respective fields.

• **TRAINED COLLEAGUES**—As a G-E engineer, you may be working with outstanding men who are responsible for the envisioning, production, and distribution of such new products as man-made diamonds, high-speed rocket and jet engines, the new heat pump, commercial atomic power reactors and electronic ovens.

• **EMPLOYEE BENEFITS**—General Electric's outstanding benefit program for you and your family includes all the usual life, accident and illness insurance and pension plans, plus a Savings and Stock Bonus Plan and discounts on G-E home appliances.

• **THE COMPANY'S FUTURE**—General Electric's investment in research can mean much to you. Forty-two major Company laboratories, dedicated to invention and innovation, will play a major role in doubling the Company's sales during the next eight years. Only through research is a company assured of future growth. For you, this growth at General Electric means new and challenging technical and managerial positions. General Electric Company, Section 959-3, Schenectady 5, N. Y.

Progress Is Our Most Important Product

GENERAL ELECTRIC